This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

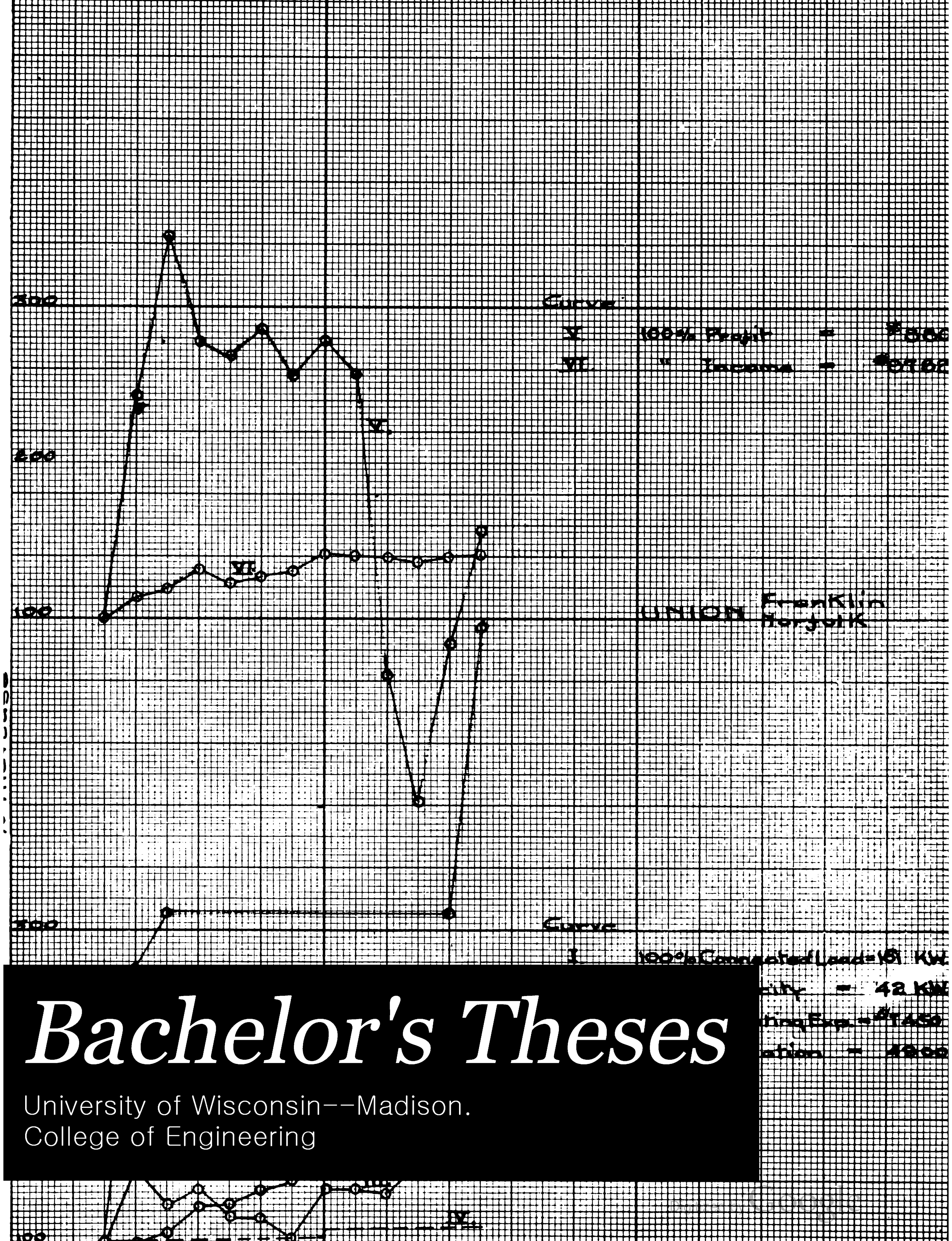
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



Bachelor's Theses

University of Wisconsin--Madison.
College of Engineering

Library
of the
University of Wisconsin

87-06

A STUDY OF CENTRAL STATION ECONOMICS WITH SPECIAL REGARD TO POPULATION CAPACITY OF PLANT AND CONNECTED LOAD

by

AVERY REEVES COLBURN

and

LAWRENCE MOSES LIBBY

A Thesis Submitted for the Degree of

BACHELOR OF SCIENCE

Electrical Engineering Course

UNIVERSITY OF WISCONSIN

1907

CONTENTS.

Page.

Introduction, ... I

Massachusetts Reports, ... 5

Method of Investigation, ... 10

Discussion of Investigation, ... 18

Conclusions, ... 27

Criticism of Reports, ... 29

Population Table , ... 33

Population Curve Sheets, ... 34

Tables showing Development and Operating

History of Plants,................................ 37

Graphical Analysis Sheets, ... 45

INTRODUCTION.

Probably one of the most rapid developments of any of the modern industries has been that of electric central station work during the last twenty years. There has been no accurate record kept of this somewhat marvelous growth except for a general survey of it contained in the special bulletins of the U. S. Census bureau and the more detailed reports of the Board of Gas and Electric Light Commission of the Commonwealth of Massachusetts. This latter report is issued annually, and contains information relative to the Massachusetts companies only. Recently New York state has organized a similar commission, but at present it is in an unstable condition.

As far as we know there has been no attempt to make a study of such reports in view of determining some general characteristics of central station development. The object of this thesis is to make such a study, tracing out the financial and operating conditions of several representative companies thru a period of years. Accordingly, the following items have received particular attention: (I) The population

of the district served, (2) The capacity of apparatus installed, in kilowatts, (3) The connected load in kilowatts, (4) The financial conditions, such as operating conditions, income, profits, valuation, etc., of each individual company. We have also separated out to some extent the revenue derived from the sale of electricity to public and private customers, and have touched upon the history of gas in the field of public lighting.

When this subject first presented itself to our minds, our attention was naturally called to Wisconsin as the most convenient and desirable state to study, in view of the fact that legislation in regard to forming a commission similar to that in Massachusetts was being agitated. We made out a circular letter and directed it to the town clerks in those localities having municipal electric plants. Out of the fifty letters we sent out, sixteen were answered. The majority of the replies were very unsatisfactory, both in regard to completeness and clearness. Messrs. Greenfield and Holben, who were endeavoring to make a study of the cost of production of electricity, had practically the same experience in trying to secure information from private plants. They re-

ceived a much smaller percentage of replies and far less satisfactory information, and were finally compelled to abandon their idea altogether.

Under the provisions of Section 5,Chapter 507 of the Laws of 1905 of the state of Wisconsin, the domestic corporations are required to file with the Secretary of State, a report sworn to by the president, secretary, treasurer, or general manager, or if the corporation is in the hands of an assignee or receiver, by such assignee or receiver. The blanks sent out by the secretary of state are to be filled out in accordance with the following:

1. The name of such corporation and location, giving street and number.

2. The name and address of the officers and directors of such corporation, giving street and number.

3. The amount of authorized capital stock.

4. The amount of capital stock actually paid in money, property and services.

5. Whether such corporation was engaged in active business during preceding year.

6. Nature of business transacted during preceding year.

7. In what states such corporation is licensed to transact business as a foreign corporation.

To enforce this law a fine of ten dollars is imposed upon the delinquent corporation if such report is not in on a set date, and if the report is not forthcoming within another specified time, the company forfeits its corporate rights and privileges. Evidently there is a great laxity on the part of the state in this matter as we were unable to obtain the information called for in the reports. However, this report does not contain sufficient data for a study of such corporations. There is before the present legislature, now in session(1906-1907)apublic utility bill. This bill contains provisions for placing all public service corporations under the supervision of the Railway Rate Commission, which has rendered such valuable service in the supervision of railways. It is thus seen that this commission will be ena--bled to secure from the central station companies any information they wish, and, judging by the complete way in which this commission has handled the railway question, there will doubtless soon be available sufficient data to make such a complete study of central station conditions in

Wisconsin.

We then entered into correspondence with different commissions and private individuals with one end in view, i.e., how to obtain data on electric central station plants. The National Electric Light Commission gave us no encouragement except to refer us to the reports of the Massachusetts Board. Previously we had sent for a complete set of these reports which covered a period of years from 1887 to 1905. In several other cases, the Massachusetts reports were referred to as the only available source of information. Inasmuch as the consensus of opinion seemed to point in that direction, we finally decided to make a study of these reports.

MASSACHUSETTS REPORTS.

In the year 1884 the Massachusetts legislature passed a bill which placed all the gas companies in the state under the strict supervision of a Board of Commissioners. The decisions of this board are final except when appeal is made to the courts. The duty of this board is to protect both the producer and the consumer. The change of rates, increase of capitalization, issue of new bonds, petitions and complaints, all receive the attention of the board.

In 1887, the electric light companies had assumed such proportions thruout the state that the legistature found it necessary to extend the jurisdiction of this commission so that the electric companies were included under this supervision. The official title of this supervising body then became " The Board of Gas and Electric Light Commissioners". The annual reports of this board are published on the first of January of each year and are obtainable for the asking.

We decided to confine our investigations strictly to that section of the reports dealing with electric light companies. Perhaps a brief outline of what these reports contain in the way of data and other information along the line of our study will assist the reader in following future discussions. Most of the information is given in tabular form. We will follow the tables as they are located in the report. The first table of interest gives the names of the companies actually engaged in the supply of electric light on June 30 of the year in question, the amount of capital stock, together with the localities supplied. Another table shows the whole number of stockholders in the companies, the number resident in Massachusetts and the value at par of the stock

held in the state. A summary of the financial operations of all the electric central stations in the state taken as a whole, showing the income, the operating expenses, also the assets and liabilities, itemized, follows. Then come tables of the assessed valuation, the taxes paid and the dividends declared by the several companies. The next table is one of greater interest to us as it shows the installation of the different plants. It includes the number of boilers, their total rated horse-power, the number of engines and total rated horse-power of same, and the number of dynamos installed for light and power. It might be stated here that the dynamo capacity is rated according to the number of lamps of a certain nominal candle-power it would supply at full load. This rating was reduced to a common basis of kilowatts capacity, which was necessary for comparison later. The table following shows the quantity of coal and other kinds of fuel used by the several companies during the year. As the price and quality of coal is not given this data is of little or no value to us. In the next table, data on the transmission and distributing systems, whether overhead or under ground, is given in some detail, the conduit system

showing an increase in the large growing towns from year to year.

Following there is a table showing the number of motors supplied on arc, incandescent and power circuits, not including those for street railway work, and the number of single and double arc lamps. In determining the total connected load this data was used. The next table shows the number of commercial lamps of different kinds installed and the number of customers for each kind of lamps. This data was also used in determining the connected load. On public lighting there is a very complete table showing the number of public lamps of each candle-power in use and the price paid, also the average number in use, with the average number of hours per night, and the number of nights per month that they were used during the year. From this data we were able to determine the connected load for public lighting and the total amount paid by the city for its public lighting during that year. This is discussed fully later. The last table in the report deals with the rates on commercial lights, whether by contract, or by meter, showing the system of sliding scale, remarks on wiring and lamp renewals and special discounts.

In the appendix are given itemized accounts including the balance sheets (assets and liabilities), manufacturing and profit and loss accounts.

Any new legislation relative to the companies and the commission is printed in full in the appendix. Special petitions on the part of the companies in regard to increasing capital stock, or issuing bonds, etc.,are given a place in the first portion of the report. All complaints of private parties and everything of importance which the board has been doing during the year is chronicled in a complete manner.

From this brief summary the scope of the commission's work can be appreciated. How accurate these returns are we are unable to judge, but will have to assume that they are correct,inasfar as our conclusions are drawn from the data contained therein. The returns are sworn to by the authorized representatives of the different companies and are carefully gone over and corrected by the board. Inaccuracies are liable to creep in as we think we have found several places where on the face of it this is obvious. Insome cases the financial statements have been difficult to follow,

probably due in the main to local conditions which we are unaware of.

METHOD OF INVESTIGATION.

From 1888 to 1893 the data given in the tables was not complete enough or sufficiently itemized so that we could use it to much advantage, consequently we started our study for the year 1893 and carried it down to the year ending 1905. There is an almost endless number of factors entering into the development we have attempted to follow, but we have only taken a few of the most important, as follows:

1. Population and locality supplied.
2. Kilowatt capacity of apparatus installed.
3. Kilowatt connected load.
4. Total income.
5. Operating expenses.
6. Profits.
7. Public lighting income.
8. Actual valuation of companies' real property.
9. Cost of operation per kilowatt connected load.

To place the different factors on a common basis we reduced all quantities to a per cent. increase or decrease,

taking the returns for the year I893 as a starting point at I00 per cent. A graphical analysis of this was placed in curve form and the discussion of each company in turn is made directly from the curves.

First we selected what we considered eight representative companies which supplied localities ranging from 5000 to I00,000 in population. They are as follows:

COMPANY'S NAME	LOCALITIES SUPPLIED	POPULATION--I900.
I. Union	Franklin and Norfolk	5,997
2. Milford	Milford	I3,463
3. Waltham	Waltham	23,48I
4. Pittsfield	Pittsfield	24,780
5. Brockton	Brockton	40,063
6. Salem	Salem	35,956
7. Cambridge	Cambridge	9I,886
8. United	Springfield, West Springfield, and Longmeadow	69,975

We then obtained data on population from the U.S. Census reports, starting with I870. On page 33 is tabulated the population with the locality supplied, showing the additional population as the companies extended operations. Popula-

tion curves were drawn (See pages 34,35,&36) and the per cent. increase was determined from them as is shown on the last column of the table on page 33 . The following factors were determined and put in tabular form, pages 37 to 45 .

KILOWATTS CAPACITY OF INSTALLATION:- This was calculated from the lamp rating of the machines. For instance, take a machine rated at 15,000 , 16 candle-power lamps: we determined the watt equivalent of an incandescent lamp candle-power which was found to be equal to 3.125 watts. So, multiplying 15,000 by 16 by 3.125, we obtain 750 kilowatts as the capacity of the machine. The watts per arc light candle-power was taken at 0.342. Thus one 1200 Candle-power arc would represent (1200 times 0.342 equals 0.410) kilowatts.

KILOWATT CONNECTED LOAD:- This was determined in the same manner, taking as the total the sum of the commercial lighting, public lighting, and the power load, reduced from the tables previously referred to. To give some idea of the variety of candle-power of the lamps used we had to reduce to the kilowatt basis an example is given below of the public lighting connected load of the Salem Company in 1900.

Number of Commercial Incandescent Lights.	Nominal Candle-power
6	4
341	6
1,398	8
,509	10
1,152	12
15,837	16
500	20
28	24
38	25
287	32
16	50
2	65
27	150

FINANCIAL DATA:- The total income, operating expenses, and profits were taken directly from the balance sheets.

PUBLIC LIGHTING INCOME:- In the tables are given the number of lights of each candle-power used by the city for public lighting. Opposite is given the price paid per lamp per year for each of the different kinds. The sum of the products of the number of lamps and the price paid per lamp

gives the total price paid by the city for public lighting. If the price paid was so much per night burned, and the average number of nights burned per month is taken from the table, we are thus able to calculate the amount paid by the city for lighting under this method of charging. The per cent. of the total income derived from public lighting was also found.

VALUATION:- From the assets on the balance sheets we determined the valuation of the company's property, omitting, however, such items as " Due for Light and Power","Sundry Accounts due Company","Cash on hand"," Notes receivable", " Insurance", "Interest advanced", "Investments", etc., which do not affect the true value of the plant. A typical balance sheet is shown below:

BALANCE SHEET FOR 1901.

Edison Electric Illuminating Company of Brockton.

Assets.

Real estate,....................................	$53,861 34
Steam plant,....................................	38,092 86
Electric plant,....................................	38,084 13
Electric lines,....................................	137,371 22

Transformers,	2,200	57
Meters,	7,893	46
Arc lamps,	16,649	30
Patent rights,	19,000	00
Due for light and power,	8,759	02#
Oil and waste on hand,	144	80
Other materials on hand,	9,149	56
Fixtures on hand,	1,477	29
Sundry accounts due the company,	549	19#
Office furniture,	1,481	97
Cash on hand,	1,340	93#
Notes receivable,	134	89#
Investments,	100,000	00#
Total assets, as per books of the company,	$436,190	53
# Subtract,	111,984	03
	$324,403	50

Liabilities.

Capital stock,	$100,000 00
Bonds issued,	100,000 00
Notes payable,	175,000 00
Unpaid bills,	5,910 63
Deposits,	25 00
Interest accrued but not due,	2,104 17
Taxes accrued but not due,	996 45
Total liabilities , as per books of the company,	$384,036 25
Profit and loss balance,	52,154 28
	$436,190 53

Manufacturing Account.

Operating expenses:		Dr.	Cr.
At station,	$25,569 68		
For distribution,	14,436 17		
management,	7,214 07		
taxes and incidentals	3,926 33		
		$51,146 25	

Income from sale of light and power,		$73,645 61
Balance to profit and loss,.........	22,499 36	
	$73,645 61	$73,645 61

Profit and Loss Account.

	Dr.	Cr.
Balance of manufacturing account,....		$22,499 36
Interest received,....................		31 90
Depreciation fund transferred,.......		55,362 03
Interest paid,.......................	$10,525 30	
Dividends declared,..................	6,000 00	
Other items,.........................	9,213 71	
Balance June 30, 1900,...............	52,154 28	
	$77,893 29	$77,893 29

In this manner we reduced the valuation of the several plants to a common basis. True, this valuation is that determined by local authorities, but on the whole it gives a fair idea of how the plants' valuation has increased from year to year. Knowing the profits, we determined the per cent. the companies were clearing over operating expenses of the to-

tal valuation of the plant.

COST OF OPERATION PER KILOWATT CONNECTED LOAD:- This was obtained by dividing the total operating expenses by the total kilowatts of the connected load.

On pages 37 to 45 are given the calculations in tabular form which we have made covering the period of time 1893--1905 for the eight companies mentioned. On pages 45 to 58 are shown the curves for graphical analysis of these companies. The year is taken as the abscissea, and the per cent. increase or decrease over the value in 1893 at 100 per cent. is taken as the ordinate. The curves are numbered and as the 100 per cent. value in 1893 is given, for any other year the value can be readily determined.

On pages 53 & 54 are drawn curves showing the cost of operation per kilowatt of the connected load.

On pages 55 & 56 are drawn curves showing the per cent. of total income received from public lighting.

DISCUSSION OF INVESTIGATION.

We will take up each company in turn, according to the size of the locality supplied, and discuss its characteristics as shown by the curves.

UNION:- The population served starting with 1893 with 4900 shows an increase of 8 per cent. up to 1905. The connected load shows an increase of about 77 per cent. during this period. This indicates that there is no general relation between the increase of population and connected load, but that the use of electricity is becoming more universal. This condition will be found true of all the plants considered, tho of course the load curve is somewhat steeper with a greater increase of population. The capacity in 1893 is 42 kilowatts, while the connected load is 161 kilowatts. This is either a mistake in the report or presents extraordinary conditions. In 1894 the capacity curve shows a jump of nearly 200 per cent. to take care of the increased connected load. It remained constant, then, until 1904, apparently being sufficient to handle the connected load. The next year, however, it took another increase of nearly 200 per cent. of the original. This last increase was probably due to some larger units being installed. The income has practically remained constant while the profits have shown a marked variation, being at a maximum in 1894 and a minimum in 1903. The operating expenses per kilowatt connected

load have also remained nearly constant as shown on curve sheet, page 53. This accounts in some respects for the fact that the profits have not been increasing with the load. An interesting detail is brought out by the amount of coal consumed by this company in 1903, the year of minimum profits. 919 tons of coal were used by this company and the United company used 1138 tons the same year, the load of the Union company being only 256, while that of the United companywas 3650 kilowatts, over ten times as much. From 1903 on the profits show a rapid increase, altho the company has not been able to pay dividends as yet. The per cent. the profits are of the valuation has never been above 5 per cent. as can be seen by the table, page 45.

MILFORD:- The population at 9750 remains practically constant, while the connected load has increased over 300 per cent. by 1905. being 90 kilowatts in 1893. The capacity shows a normal increase, except for a sudden jump in 1901, being at a maximum of 400 per cent. over the original in 1893, of 124 kilowatts. The sudden jump in connected load a year before this probably influenced the management to increase the capacity of the plant considerably, but the loss

of some business later probably caused them to take it out. The operating expenses have remained nearly constant. The fact that this company buys its steam, in all probability keeps down the operating expenses to a low figure. The income of $14000 remains constant until 1899. Since then it has shown a decided increase. The profits during this period also have a marked increase. This company has been declaring nothing less than 6 per cent. dividends. This illustrates what a well managed company can do, taking advantage of the opportunity of getting cheap power to run its plant. As shown on the curve sheet on page 53 the cost of operation per kilowatt of connected load has decreased very decidedly starting in 1893 at $131 per kilowatt year, to $39 per kilowatt year in 1900, where it has remained constant.

PITTSFIELD:- Population shows an increase of about 26 per cent. while the connected load increases over two and a half times that of the original 496 kilowatts in 1893, denoting as stated in the discussion of the Union Company, the great increase in the use of electricity. Of course the power users are becoming more general, especially in shops. The sudden dip of the load curve in 1901 is probably due to

some local condition, such as a large consumer moving away or installing a plant of his own. The capacity curve shows a normal increase, keeping somewhat below that of the connected load. The income curve shows a steady rate of increase, but not as marked as that of the load. This would seem to indicate that the rates have been reduced to a considerable extent or that the use of cheap power has very greatly increased. While we have not plotted any curve showing the relation of power to lighting load, still we have noted from year to year that the per cent. has remained practically constant. This would lead to the conclusion that the former condition has prevailed. This is borne out by the run of rates from year to year as shown in the reports, but since the company has gradually changed from a flat rate to a meter rate basis of charging, it is next to impossible to obtain any comparative data of value. This may be said also of the sliding scale method of charging. The operating expense curve, after the first two years, fluctuates considerably, but tends to remain about constant. The cost of operation per kilowatt of connected load shows a very slight decrease. The very unsteady profit curve bears this out,

showing that if the cost of operation per kilowatt of connected load had shown a normal decrease, the profit curve would have shown a more normal increase. It is a peculiarincident that in 1898 the company petitioned the board for permission to increase its capital stock, to enable it to add more capacity to the plant. The following two years the profits and capacity took a sudden slump. This, of course, is only natural with the profits, but it would seem as tho there would be some increase of capacity shown. It may be, however, that several old machines were taken out and a machine of better efficiency but less rated capacity was put in. In 1900, 7 per cent. dividends were declared and in 1898,12 per cent. dividends. Since 1900 8 per cent. dividends have been the rule. The per cent. that the profits are of the valuation of the plant has varied from 5 to 9 per cent. during the period studied.

WALTHAM:- This is a case of an electric and a gas company under the same management. We have separated out the electrical installation from that of the gas in formulating our results. Starting with a population of 19,700 in 1893, there has been an increase of about 35 per cent. up to 1905.

A notable fact in this company's development is the low capacity of the plant in comparison with its connected load. The curve sheet, page 48, shows this point very well. The operating expense curve follows pretty closely that of capacity. Altho the profits show a decided decrease for the first few years after 1893, this is modified by the fact that the gas end of the plant has neutralized this factor so that the company has been able to pay dividends continuously. Since 1900 the income and profits have taken a rapid advance and the electrical end of the plant is more than holding its own at present.

SALEM:- In 1893, the population of Salem was 32,500 and has increased 17 per cent. up to 1905. The connected load increase is very rapid, but the profits and income have not shown a normal increase until within the last three or four years. The operating expenses have been kept down, as the curve shows. The fact that the capacity has increased more rapidly in per cent. than the connected load might account for these seeming stagnant conditions of this plant. The cost of operation per kilowatt year of connected load has shown a steady decrease, being $120 in 1893 and $40 in 1900.

Since then there has not been much change. It is a notable fact that the per cent.thatthe total profit is of the valuation of the plant has been over 13 per cent. and has been since 1893 as high as 6 per cent. This company also has been paying dividends continuously. Good management has made this company a paying proposition in spite of certain peculiarities pointed out previously.

BROCKTON, UNITED, CAMBRIDGE:- These three companies show the same general characteristics. Each city has had a healthy growth of population and the connected load of each is having a marvelous increase. The capacity of each company falls somewhat below the connected load, and the operating expense below this. This is normal conditions of a well managed plant with business on the increase. Another element of similarity of these companies is shown by the profit and income curves. They follow each other closely and have the same general increase. As it would seem, the profits, income and connected load are gradually increasing at a faster rate which shows how thoroly these companies have worked their territories. Substantial dividends have been declared by these companies from the start. Probably the nearest ap-

proach to a general rule or ideal conditions is shown by the curves of these three companies.

Page 57 gives a study of the gas and electric business in two towns taken at random. While not very complete on account of the fact that there is no data given on the candle-power and the number of gas lamps, still these curves show some points of interest. Curve 2 shows the per cent. of receipts from public electric lights to receipts from public lamps of all kinds. It will be noticed that this percentage increases rapidly in each case to 100 per cent., thus showing how the electric light has superseded the gas light for public lighting. Curve I shows the price of gas in per cent. of the price in 1888. This is interesting in showing the inevitable fall in price. This is no doubt true also of electric rates, but the reports do not give the necessary data to make such a curve. Curve 3 shows the per cent. of electric receipts to the total receipts for light, power, and heating, thus indicating that the gas is holding its own in spite of the fact that these towns are using electricity for street lighting.

CONCLUSIONS.

Taking the set of curves as a whole, there are a few main points of similarity which may well be emphasized. In the first place, it is shown in every case that the connected load in a particular locality is growing at a much greater rate than the population; also that in all cases there has been no falling off in rate of load increase during the last year, thus indicating that in Massachusetts the central station business is still on the increase with no indication of its having reached the limit.

The question of the relation of the capacity of a plant to its load output is a very interesting one to central station men and these curves present some data on the subject. In nearly all cases it is seen that a general load such as these curves represent can be carried with a much less capacity of plant than the actual connected load. The relation of capacity to connected load varies from a minimum of about 40 per cent. to a maximum of about 80 per cent. (except in the case of the Union Company, which had a minimum of about 25 per cent.), the majority of them being slightly above 60 per cent.

Another general characteristic is that in a majority of cases the curve of operating expenses follows that of capacity rather than that of connected load. This would indicate that it is better practice to get along with as little capacity as can conveniently handle the load. This is a fact well known to engineers, but in central station work of this kind a certain reserve should be carried to allow for the rapid increase of load,such as has been shown to be the case, and to secure continuous service under all conditions. In the absence of data on the price of fuel and wages the curves would show that the standby charge is evidently a greater item than that of fuel.

The decrease in rates is shown by the fact that in most instances the slope of the income curve is much less than that of the connected load curve. However, in the better managed companies the operating expenses have been cut down to such an extent that these companies have been making substantial profits in spite of the decrease in rates. The decrease of operating expenses per kilowatt connected load is better shown in the special sets of curves on pages 53 and 54. One point of resemblance of this set of curves is that

the cost of operation has evidently about reached a minimum as there has been very little decrease in any of them during the last few years.

Finally, viewing the curves as a whole, one notes the more uniform curves in the case of the larger companies. This is due, no doubt, to the better financing and management which we will meet with in the larger companies. The smaller companies probably passed thru many changes in management and equipment , so that there is a less uniformity in the results obtained.

CRITICISM OF REPORTS.

It will be seen that these reports have been lacking in data of real value in the study we have been making. In the first place, the most essential thing to know about a central station business is the kilowatt hour output. Without this data no accurate estimate can be made on what rates should be. This will be appreciated, when we consider that if a company in a certain locality has a large number of factory lamps on its lines running all night, it is evident they would have a better business than a company having the same number of connected lamps but doing mainly residence

lighting, altho in the tables it would appear as if each company had the same amount of business. The separation of the kilowatt hours of connected load into its component parts such as arc and incandescent lighting and power, would give a better idea of the character of the company's business, its actual money value, and the nature of the demand made upon its service, and the income derived from these sources, if itemized, would assist in determining the relative desirability of the different kinds of load. These items being known, a schedule of fair rates could be established, and it would then be evident whether or not the companies were charging too high rates. Probably some of this information is turned in to the Board but is withheld from the general public. This is due to the fact that, to one unacquainted with the whole subject of central station economics, it might appear that some companies are exacting exhorbitant rates, while this might not be true. Thus great dissatisfaction would most likely arise, which would no doubt be a great hindrance to the Board in its work.

Another item which would be of great value in this study is the price and quality of coal. The tons of coal are given

in each case but no description of the kind or price. It is a well known fact that the heating value of coal varies thru a wide range and thus it will be seen that the mere item of the amount burned is of no practical value unless some idea is given of the quality. If the price were given, it would serve as an index as to how efficiently the plant was run.

A factor of great importance in affecting operating expenses is the matter of wages. This would tend to be of more importance the smaller the plant. Therefore it would be of great value in figuring standby charges if a schedule of wages to employees were given, also the number employed.

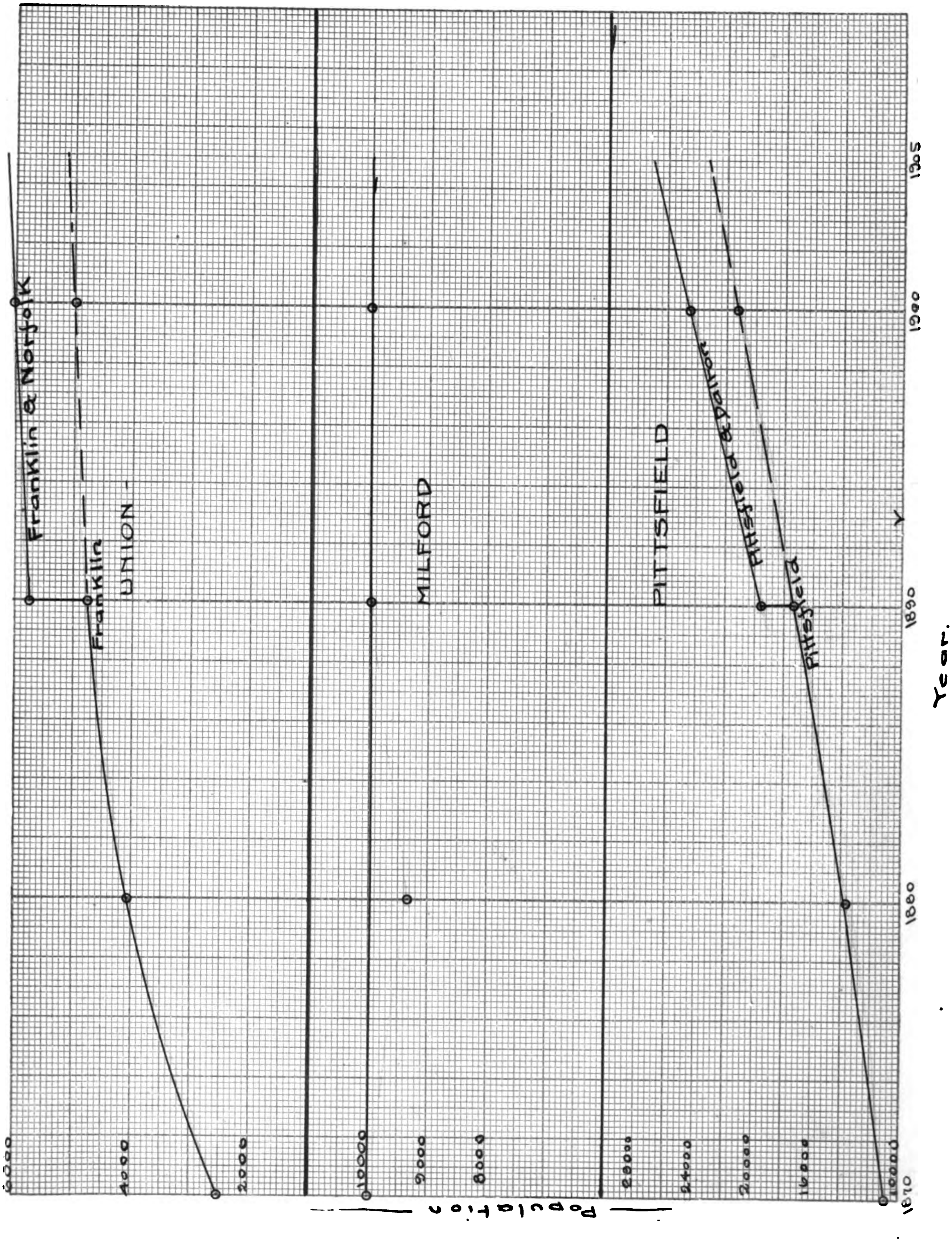
More complete data should also be given in regard to the financing of the different companies. Under this head comes the question of capital stock, and in this regard it is of prime importance to know, not alone the authorized stock, but the stock actually paid in.

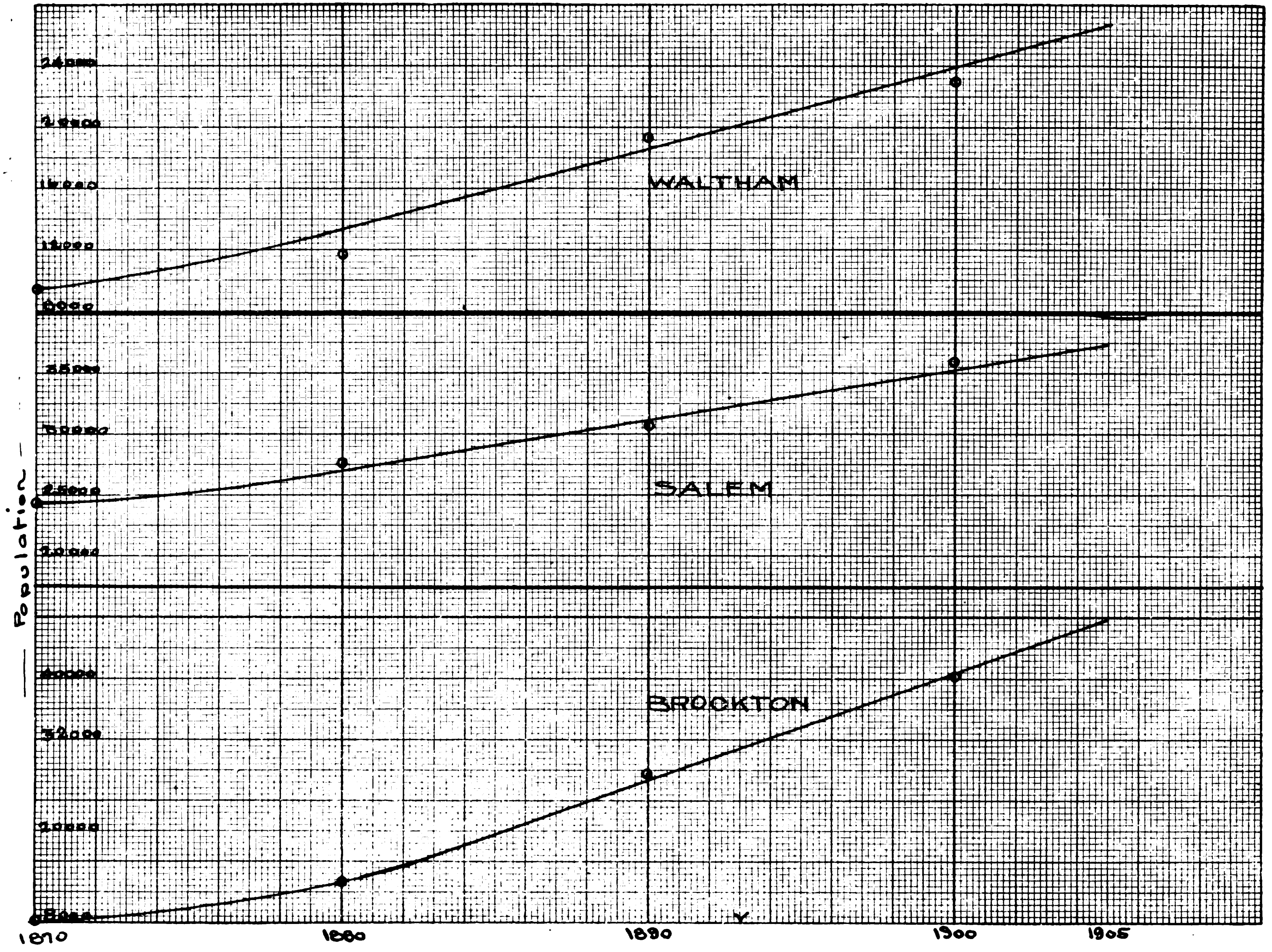
As a general summary of the points brought out by this study we will mention the following: Wisconsin has had up to this time, quite primitive and ineffective regulation of its public service corporations, but with the legislation

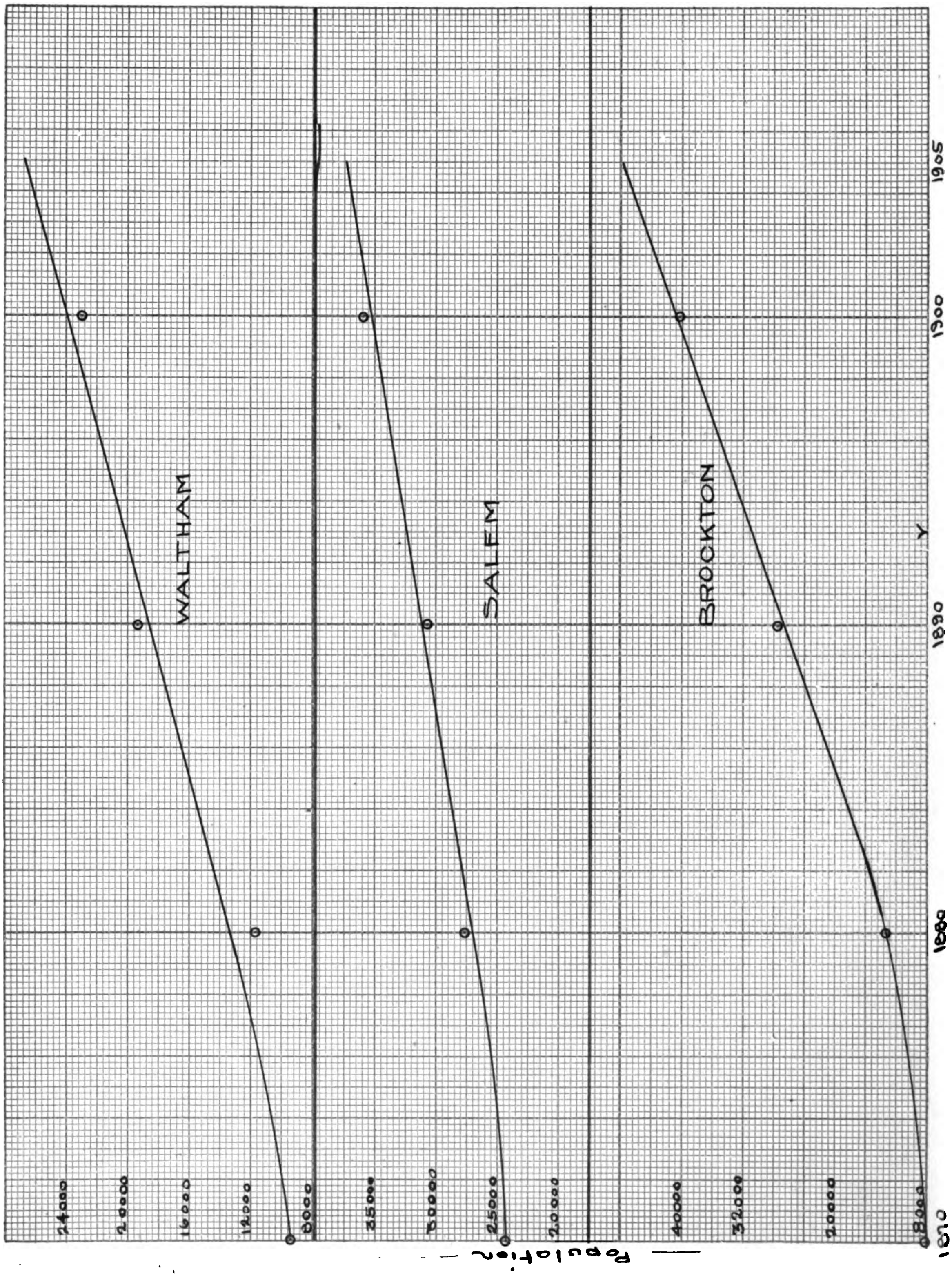
recently enacted, a new field for economic investigation will no doubt be opened. Massachusetts has far outstripped most other states in regard to regulating its corporations, consequently its fund of information is most complete in this line, but is still far from perfect. Our method of investigation has shown that it is necessary to reduce all the factors entering into a company's development to a common basis, and that a graphical analysis presents the subject as a whole much better than tables alone. By selecting representative companies, serving districts whose population varies from that of a small town to that of a large city, we have covered the average conditions met with in central station practice. We have thus deduced certain conclusions in regard to the comparative relations existing between population served, capacity of plant, connected load, and financial operations, which may add something of interest to the study of economic conditions in the rapidly developing field of central station work.

Table showing Population of localities supplied, from 1870 to 1900, and percent. increase from 1893 to 1905.

Company	Locality supplied	1870	1880	1890	1900	% increase 1893-1905
Union	Franklin	2512	4051	4744	4997	
	Norfolk			1000	1000	
	Total	"	"	5744	5997	8%
Milford	Milford	9890	9310	9956	10120	
	Total	"	"	"	"	3
Pittsfield	Pittsfield	11112	13364	17289	21766	
	Dalton			2885	3014	
	Total			20174	24780	33
Waltham	Waltham	9606	11712	18707	23481	
	Total	"	"	"	"	31
Salem	Salem	24117	27560	30801	35956	
	Total	"	"	"	"	17
Brockton	Brockton	8007	13608	27290	40063	
	Total	"	"	"	"	51
United	Springfield	26703	33340	44179	62058	
	W "			5077	7105	
	Longmeadow			2183	1998	
	Total			51439	71156	53
Cambridge	Cambridge	39634	52669	70280	91886	
	Total					37


Franklin & Norfolk
Franklin
Franklin
UNION
MILFORD
PITTSFIELD
Pittsfield & Dalton
Pittsfield
Year
1870
1880
1890
1900
1905
Population
6000
4000
2000
10000
9000
8000
28000
24000
20000
16000
10000


WALTHAM
SALEM
BROCKTON
24000
20000
16000
12000
8000
35000
30000
25000
20000
40000
32000
20000
8000
— Population —
1870
1880
1890
1900
1905


WALTHAM
SALEM
BROCKTON
24000
20000
16000
12000
8000
35000
30000
25000
20000
40000
32000
20000
8000
1870
1880
1890
Y
1900
1905
Population

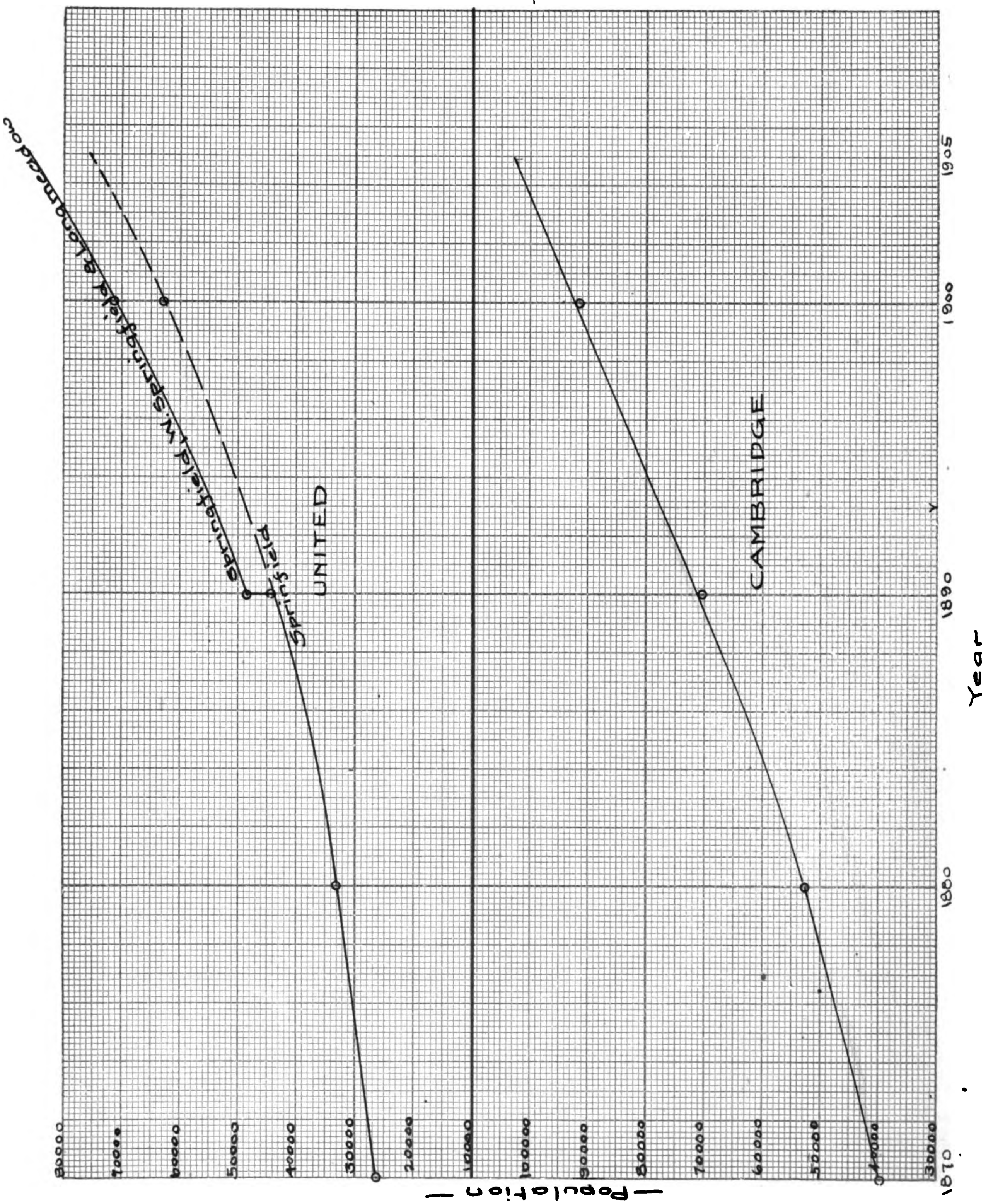

Springfield W. Springfield & Longmeadow
Springfield
UNITED
CAMBRIDGE
Year
1870
1880
1890
1900
1905
— Population —
80000
70000
60000
50000
40000
30000
20000
10000
100000
90000
80000
70000
60000
50000
40000
30000

Table showing development and operating history of the Union Electric Co.

Year	1893	94	95	96	97	98	99	1900	01	02	03	04	05
KW Capacity	42	116	130	130	130	130	130	130	130	130	130	146	207
% of original capacity in '93	100	277	310	310	310	310	310	310	310	310	310	348	495
KW Connected load	161	125	170	197	200	215	225	250	246	251	264	252	277
% of original connected load	100	77	106	122	124	133	140	155	153	156	164	156	172
Total Income	$ 8782	9353	10488	11600	10700	11100	11450	12500	12300	12200	11950	12280	12300
% of original income in '93	100	113	119	132	122	126	130	142	140	139	136	140	141
Operating Exp	$ 7450	10900	9190	9990	8639	8560	7640	10120	9990	9927	11190	11450	10960
% of operating expense in '93	100	146	123	134	116	115	102	136	134	133	150	153	147
Profits	$ 880	2136	3030	2440	2350	2560	2260	2473	2280	571	* 732	746	1336
% of original profits in '93	100	243	345	277	268	286	256	278	257	65	−83	85	157
Pub light income	$ 3550	2980	3970	3777	3877	3777	4390	3337	3892	3900	3900	3980	3982
% public of total income	40	30	38	33	35	32	38	27	32	32	33	32	32
Valuation	$ 50833	53350	53500	63060	63800	65400	65200	68400	68100	69132	70100	70500	72200
% profits of valuation	1.7	4.	5.7	3.9	3.7	4.	3.4	3.6	3.4	0.8	* 1.1	1.1	1.6
Cost of operation per KW load	$ 49.50	59.00	54.00	50.50	42.00	39.70	33.90	40.00	40.50	39.50	45.00	42.80	39.50

* Loss.

Table showing development and operating history of the Milford Electric Co.

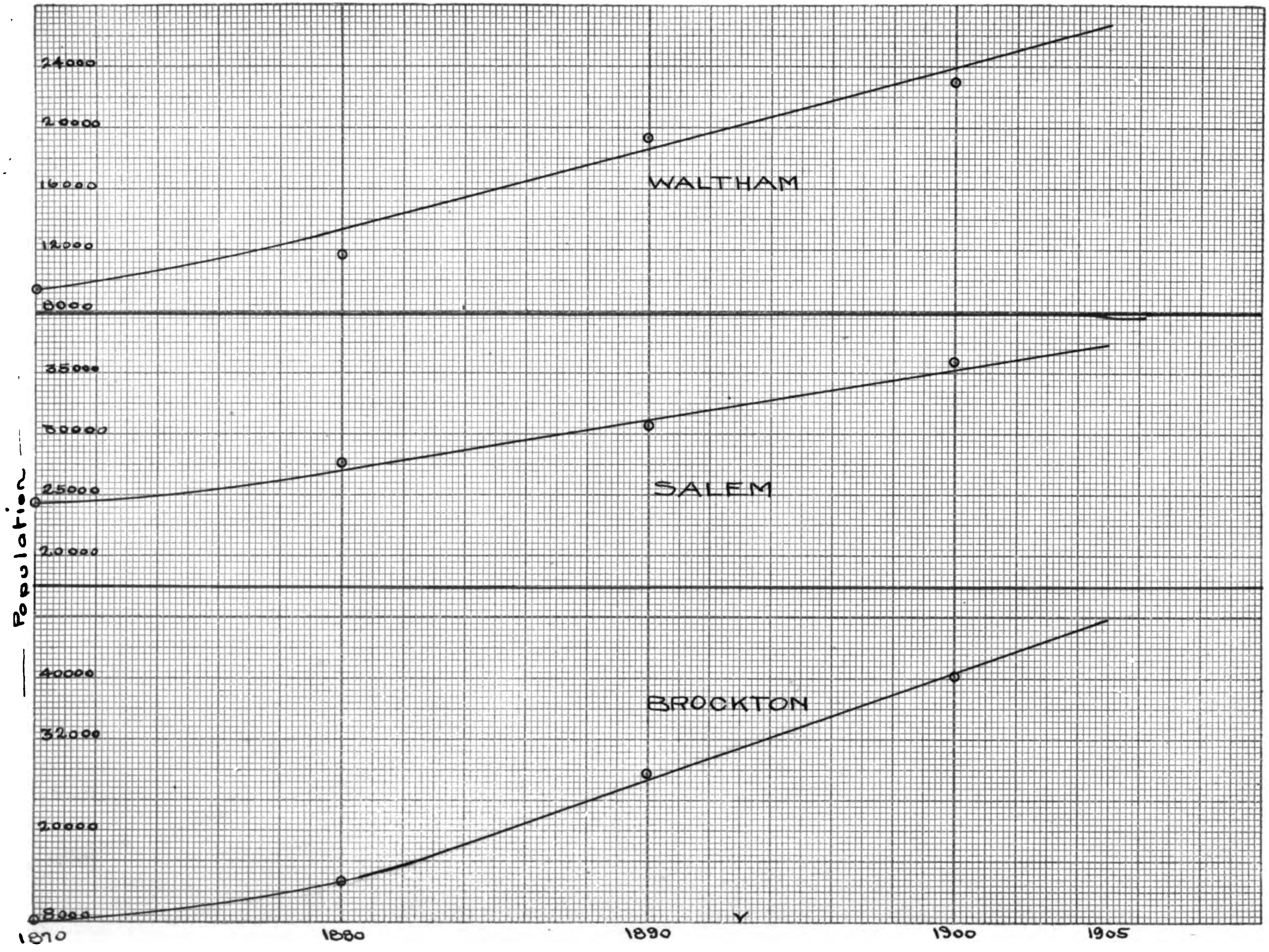
Year	1893	'94	'95	'96	'97	'98	99	1900	'01	'02	'03	04	'05
KW Capacity.	124	111	111	111	104	140	336	386	636	500	250	250	280
% of original capacity in '93	100	89	89	89	84	124	270	312	515	404	202	202	226
KW Connected load.	90	90	104	120	144	164	240	245	236	254	282	364	378
% of original connected load in '93	100	100	115	133	160	182	266	306	265	282	319	404	420
Total Income	$ 13900	12760	12795	11938	12830	12900	13450	16500	21200	16300	18130	21300	21200
% of original income in '93	100	92	92	86	92	93	96	118	152	117	130	153	152
Operating Exp	$ 11786	10102	10048	10350	11130	9603	10730	10510	15011	11030	11930	14500	14740
% of original operating expense	100	86	85	88	95	81	91	89	128	94	102	123	125
Profits	$ 2110	2661	2746	1590	1800	3300	2710	6000	6140	5290	6190	6780	6450
% of original profits in '93	100	121	130	73	85	156	127	184	291	250	292	320	305
Pub light income	$ 4040	5200	5000	5480	6220	6244	6500	6710	7330	7250	7230	6890	7840
% Public of total income	29	41	39	46	48	48	48	41	35	45	40	32	37
Valuation	$ 67195	78900	69584	70230	71275	72500	85121	79230	81100	81200	78270	64900	66600
% profits of valuation	3.1	3.4	4.0	2.3	2.5	4.5	3.2	7.7	7.6	6.5	7.9	10.4	9.7
Cost of operation per KW load	$ 131.00	112.00	98.50	86.20	77.00	58.60	44.70	38.30	63.80	43.40	42.40	40.00	39.00

Table showing development and operating history of the Pittsfield Electric Co.

Year	1893	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04	'05
KW Capacity	477	495	578	1004	1000	1000	852	740	1040	750	640	900	900
% of capacity in 1893	100	104	112	210	210	210	178	155	218	157	134	189	189
KW Connected load.	496	541	662	782	833	1009	1188	1258	1135	1281	1421	1507	1832
% of original connected load	100	109	133	157	168	203	239	254	229	258	287	304	369
Total Income	$ 50859	49320	55360	59760	66512	73126	74680	83350	86713	87240	98320	115740	122360
% of original income	100	97	109	118	131	144	147	163	170	172	193	227	241
Operating Exp.	$ 34960	35602	35931	40015	45215	46370	53650	66750	66450	62480	83550	99100	92057
% of original operating expense.	100	102	103	114	129	132	154	191	190	178	239	283	263
Profit	$ 15891	13867	19430	20172	21297	26760	21018	16593	20266	24770	14780	16633	30310
% of original profit	100	87	122	127	134	168	132	104	127	156	93	105	191
Public light income	$ 8760	9450	10182	10860	13164	13788	14280	14921	16285	16103	16040	15757	16530
% Public of total	17	19	18	18	20	19	19	18	19	18	16	14	14
Valuation	$183946	192360	190630	192855	217359	210540	213060	202891	233581	249177	280200	329251	338500
% Profits of Valuation	8.6	7.2	10.2	10.5	9.8	12.7	9.9	8.2	8.7	9.9	5.3	5.1	7.9
Cost of operation per KW load	$ 70.50	65.80	54.30	51.30	54.30	46.30	45.00	52.00	58.80	48.80	57.00	66.00	50.00

Table showing the development and operating history of the Waltham Gas & Electric Co.

Year	1893	'94	95	96	97	98	99	1900	01	02	03	04	05
KW Capacity	548	548	618	678	637	658	658	690	711	772	808	1254	1162
% of original capacity in 93	100	100	113	123	120	120	120	130	130	140	147	229	212
KW Connected load	258	334	396	485	519	537	598	684	780	872	994	1114	1100
% of original Connected load	100	130	154	188	201	208	232	265	302	332	387	488	430
Total Income	$ 42215	39520	37720	41464	39400	42300	46670	49680	63100	78500	93630	100600	96400
% of original income in '93	100	94	89	98	94	100	111	118	150	186	222	238	228
Operating Exp	$ 34850	33720	34500	38600	37400	37000	36078	41080	44500	52720	69700	69450	67100
% of operating expenses in '93	100	97	99	111	107	106	103	118	128	151	200	199	193
Profits	$ 10500	5800	3230	2820	2020	7250	10590	8600	18540	25740	23940	31240	29270
% of original profits in '93	100	55	32	27	19	69	100	82	177	245	239	298	278
Pub light income	$ 8230	8820	9660	12000	12940	13110	13260	13620	15720	12900	18900	18600	24600
% public of total income	19	22	26	29	31	33	28	27	25	16	20	18	25
Valuation	$128129	140800	140700	175800	164800	110600	108000	102800	121400	186113	176900	220500	173200
% Profits of valuation	8.2	4.1	2.2	1.6	1.2	6.5	9.8	8.3	15.0	14.0	13.6	14.0	17.0
Cost of operation per KW load	$ 135.00	100.00	87.00	79.61	72.00	69.00	60.00	60.00	57.00	60.40	70.00	62.00	61.00


24000
20000
16000
12000
8000
WALTHAM
35000
30000
25000
20000
SALEM
40000
32000
20000
8000
BROCKTON
Population
Y
1870
1880
1890
1900
1905

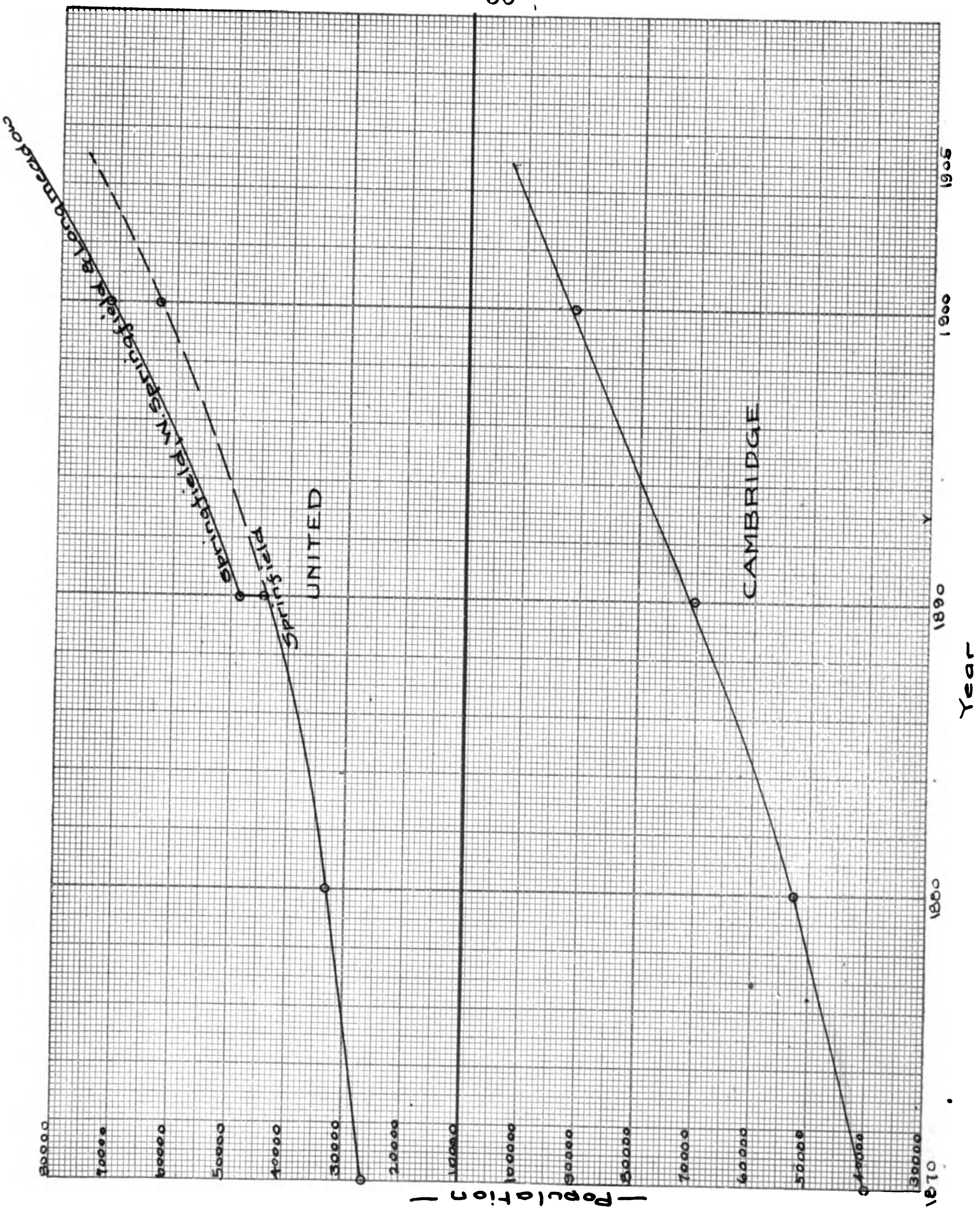

Springfield, W. Springfield & Longmeadow
Springfield
UNITED
CAMBRIDGE
80000
70000
60000
50000
40000
30000
20000
10000
100000
90000
80000
70000
60000
50000
40000
30000
— Population —
1870
1880
1890
1900
1905
Year

Table showing development and operating history of the Union Electric Co.

Year	1893	94	95	96	97	98	99	1900	01	02	03	04	05
KW Capacity	42	116	130	130	130	130	130	130	130	130	130	146	207
% of original capacity in '93	100	277	310	310	310	310	310	310	310	310	310	348	495
KW Connected load	161	125	170	197	200	215	225	250	246	251	264	252	277
% of original connected load	100	77	106	122	124	133	140	155	153	156	164	156	172
Total Income	$ 8782	9953	10488	11600	10700	11100	11450	12500	12300	12200	11950	12280	12300
% of original income in '93	100	113	119	132	122	126	130	142	140	139	136	140	141
Operating Exp	$ 7450	10900	9190	9990	8639	8560	7640	10120	9990	9927	11190	11450	10960
% operating expense in '93	100	146	123	134	116	115	102	136	134	133	150	153	147
Profits	$ 880	2136	3030	2440	2350	2560	2260	2473	2280	571	* 732	746	1336
% original profits in '93	100	243	345	277	268	286	256	278	257	65	−83	85	157
Pub light income	$ 3550	2980	3970	3777	3877	3777	4390	3337	3892	3900	3900	3980	3982
% public of total income	40	30	38	33	35	32	38	27	32	32	33	32	32
Valuation	$ 50833	53350	53500	63060	63800	65400	65200	68400	68100	69132	70100	70500	72200
% profits of Valuation	1.7	4.	5.7	3.9	3.7	4.	3.4	3.6	3.4	0.8	* 1.1	1.1	1.6
Cost of operation per KW load	$ 49.50	59.00	54.00	50.50	42.00	39.70	33.90	40.00	40.50	39.50	45.00	42.80	39.50

* Loss.

Table showing development and operating history of the Milford Electric Co.

Year	1893	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04	'05
KW Capacity.	124	111	111	111	104	140	336	386	636	500	250	250	280
% of original capacity in '93	100	89	89	89	84	124	270	312	515	404	202	202	226
KW Connected load.	90	90	104	120	144	164	240	245	236	254	282	364	378
% of original connected load in '93	100	100	115	133	160	182	266	306	265	282	319	404	420
Total Income	$ 13900	12760	12795	11938	12830	12900	13450	16500	21200	16300	18130	21300	21200
% of original income in '93	100	92	92	86	92	93	96	118	152	117	130	153	152
Operating Exp	$ 11786	10102	10048	10350	11130	9603	10730	10510	15011	11030	11930	14500	14740
% of original operating expense	100	86	85	88	95	81	91	89	128	94	102	123	125
Profits	$ 2110	2661	2746	1590	1800	3300	2710	6000	6140	5290	6190	6780	6450
% of original profits in '93	100	121	130	73	85	156	127	184	291	250	292	320	305
Pub light income	$ 4040	5200	5000	5480	6220	6244	6500	6710	7330	7250	7230	6890	7840
% Public of total income	29	41	39	46	48	48	48	41	35	45	40	32	37
Valuation	$ 67195	78900	69584	70230	71275	72500	85121	79230	81100	81200	78270	64900	66600
% profits of valuation	3.1	3.4	4.0	2.3	2.5	4.5	3.2	7.7	7.6	6.5	7.9	10.4	9.7
Cost of operation per KW load	$ 131.00	112.00	98.50	8620	77.00	5860	44.70	38.30	63.80	43.40	42.40	40.00	39.00

Table showing development and operating history of the Pittsfield Electric Co.

Year	1893	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04	'05
KW Capacity	477	495	578	1004	1000	1000	852	740	1040	750	640	900	900
% of capacity in 1893	100	104	112	210	210	210	178	155	218	157	134	189	189
KW Connected load.	496	541	662	782	833	1009	1188	1258	1135	1281	1421	1507	1832
% of original connected load	100	109	133	157	168	203	239	254	229	258	287	304	369
Total Income	$ 50859	49320	55360	59760	66512	73126	74680	83350	86713	87240	98320	115740	122360
% of original income	100	97	109	118	131	144	147	163	170	172	193	227	241
Operating Exp.	$ 34960	35602	35931	40015	45215	46370	53650	66750	66450	62480	83550	99100	92057
% of original operating expense.	100	102	103	114	129	132	154	191	190	178	239	283	263
Profit	$ 15891	13867	19430	20172	21297	26760	21018	16593	20266	24770	14780	16633	30310
% of original profit.	100	87	122	127	134	168	132	104	127	156	93	105	191
Public light income	$ 8760	9450	10182	10860	13164	13788	14280	14921	16285	16103	16040	15757	16530
% Public of total	17	19	18	18	20	19	19	18	19	18	16	14	14
Valuation	$183946	192360	190630	192855	217359	210540	213060	202891	233581	249177	280200	329251	338500
% Profits of Valuation	8.6	7.2	10.2	10.5	9.8	12.7	9.9	8.2	8.7	9.9	5.3	5.1	7.9
Cost of operation per KW load	$ 70.50	65.80	54.30	51.30	54.30	46.30	45.00	52.00	58.80	48.80	57.00	66.00	50.00

Table showing the development and operating history of the Waltham Gas & Electric Co.

Year	1893	'94	95	96	97	98	99	1900	01	02	03	04	05
KW Capacity	548	548	618	678	637	658	658	690	711	772	808	1254	1162
% of original capacity in 93	100	100	113	123	120	120	120	130	130	140	147	229	212
KW Connected load	258	334	396	485	519	537	598	684	780	872	994	1114	1100
% of original Connected load	100	130	154	188	201	208	232	265	302	332	387	438	430
Total Income	$ 42215	39520	37720	41464	39400	42300	46670	49680	63100	78500	93630	100600	96400
% of original income in '93	100	94	89	98	94	100	111	118	150	186	222	238	228
Operating Exp	$ 34850	33720	34500	38600	37400	37000	36078	41080	44500	52720	69700	69450	67100
% of operating expenses in '93	100	97	99	111	107	106	103	118	128	151	200	199	193
Profits	$ 10500	5800	3230	2820	2020	7250	10590	8600	18540	25740	23940	31240	29270
% of original profits in '93	100	55	32	27	19	69	100	82	177	245	239	298	278
Pub light income	$ 8230	8820	9660	12000	12940	13110	13260	13620	15720	12900	18900	18600	24600
% of public of total income	19	22	26	29	31	33	28	27	25	16	20	18	25
Valuation	$128129	140800	140700	175800	164800	110600	108000	102800	121400	186113	176900	220500	173200
% Profits of valuation	8.2	4.1	2.2	1.6	1.2	6.5	9.8	8.3	15.0	14.0	13.6	14.0	17.0
Cost of operation per KW load	$ 135.00	100.00	87.00	79.61	72.00	69.00	60.00	60.00	57.00	60.40	70.00	62.00	61.00

Table showing development and operating history of the Salem Electric Co.

Year	1893	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04	'05
KW Capacity	545	497	783	869	1197	1155	1543	1440	1432	1656	2562	2362	2379
% of original capacity	100	91	144	160	216	212	284	264	263	304	470	433	436
KW Conn. load	670	797	873	1054	1181	1448	1494		1950	2057	2149	2374	2493
% of original connected load in '93	100	119	130	157	177	216	223		291	317	321	353	372
Total Income.	$101503	96392	83493	90241	89388	94130	92500	98020	98080	105950	115391	122230	138267
% of original income in '93	100	95	82	89	87	93	91	97	97	104	113	121	137
Operating Exp.	$ 64980	63313	66045	59500	56299	62810	64370	63550	71530	68273	89000	83970	83530
% of operating expenses in '93	100	93	87	92	87	97	99	94	100	105	137	129	127
Profits	$ 36526	33080	27450	30728	33085	31320	28146	34480	26550	37680	28380	38360	54738
% of original profits in '93	100	91	75	84	91	86	83	94	73	85	72	105	150
Public light income	$ 39200	39200	41500	41700	39280	39900	40100		35070	37300	38560	41720	42056
% Public of total income.	39	41	50	46	44	45	46		36	35	34	34	30
Valuation	$286610	260782	262160	266980	267161	260000	243801	257280	271947	309710	373686	362000	349940
% Profits of valuation.	12.7	12.7	10.5	11.5	12.4	12.0	11.5	134	9.8	12.2	7.1	10.5	6.3
Cost of operation per KW load	$ 119.00	127.00	71.90	68.50	48.00	54.60	41.60		50.00	41.30	34.70	35.50	35.20

Table showing development and operating history of the Edison Illuminating Co. of Brockton.

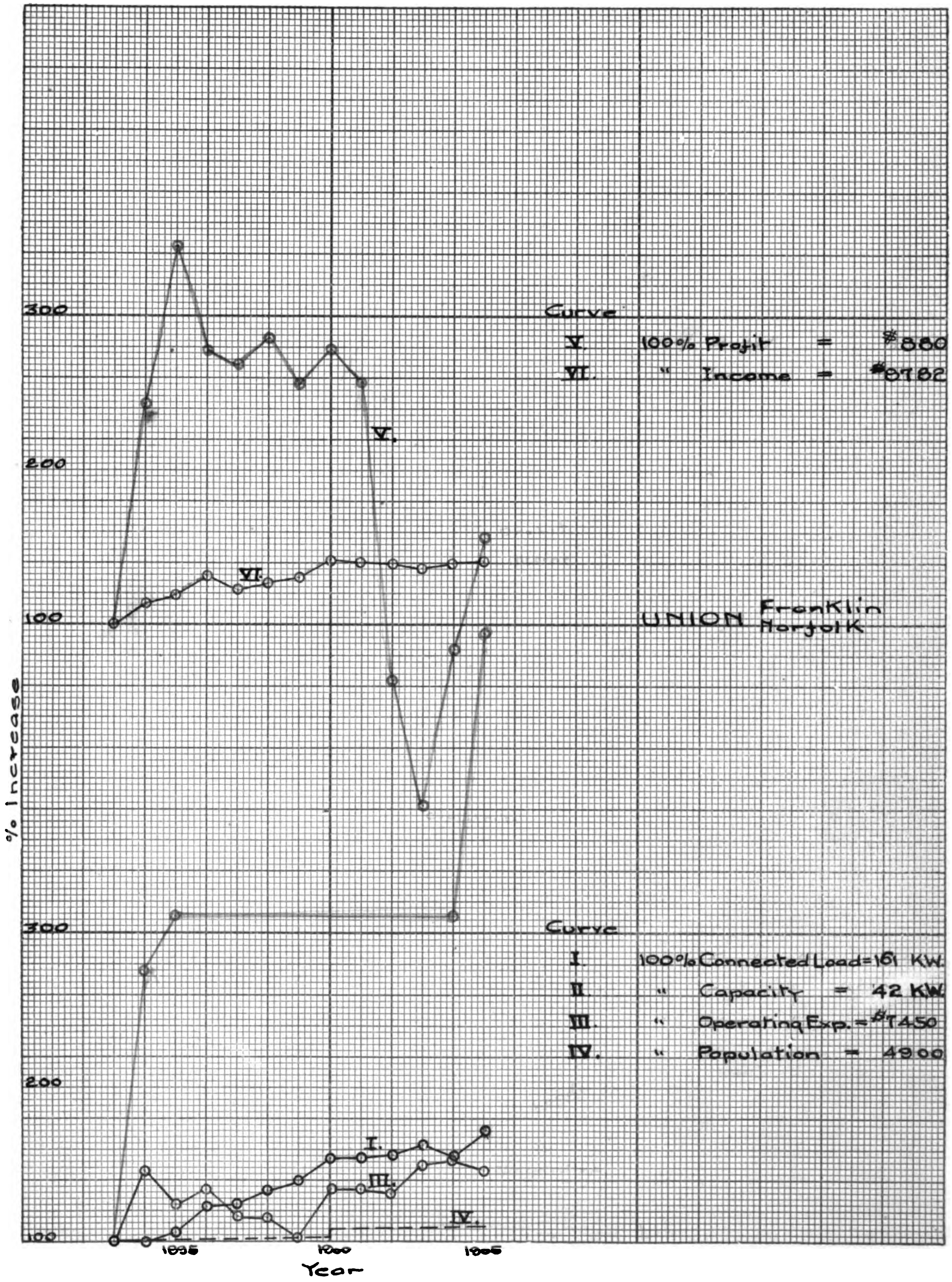
Year	1893	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04	'05
KW Capacity	555	555	596	654	659	686	807	807	787	852	1148	1890	1774
% of original capacity in '93	100	100	107	118	119	123	145	145	142	171	207	343	320
KW Connected load	566	675	557	1104	1166	960	1132	1161	1191	1593	1849	2029	2341
% of original connected load.	100	121	100	198	209	178	203	209	215	297	332	365	421
Total Income	$ 62460	59570	61249	63460	65928	68450	72100	73640	80800	90500	101560	110000	131600
% of original income in '93	100	94	98	102	105	110	115	118	129	145	163	177	211
Operating Exp	$ 41550	42020	44500	42430	43870	45050	46230	51150	54990	55930	73740	62920	90024
% of operating expenses in '93	100	101	107	102	105	108	111	123	132	134	177	151	217
Profits	$ 20900	17550	16700	21030	22100	23400	25900	22500	25820	34970	28730	47650	42400
% of original profits in '93	100	84	80	104	106	112	124	108	123	167	133	228	202
Pub light income	$ 18060	20970	38550	25580	27475	28100	29100	25100	25800	26170	31200	33000	37300
% public of total income	29	35	63	40	42	41	40	34	32	29	31	30	28
Valuation	$ 266140	271111	287700	295900	303000	312200	320800	324500	364100	398900	450300	494000	433100
% profits of valuation	7.8	6.5	6.0	7.1	7.3	7.5	7.9	7.0	7.1	8.7	6.2	9.7	9.8
Cost of operation per KW load	$ 75.00	62.50	80.00	38.40	37.70	47.00	41.00	44.00	46.00	35.00	40.00	31.00	38.50

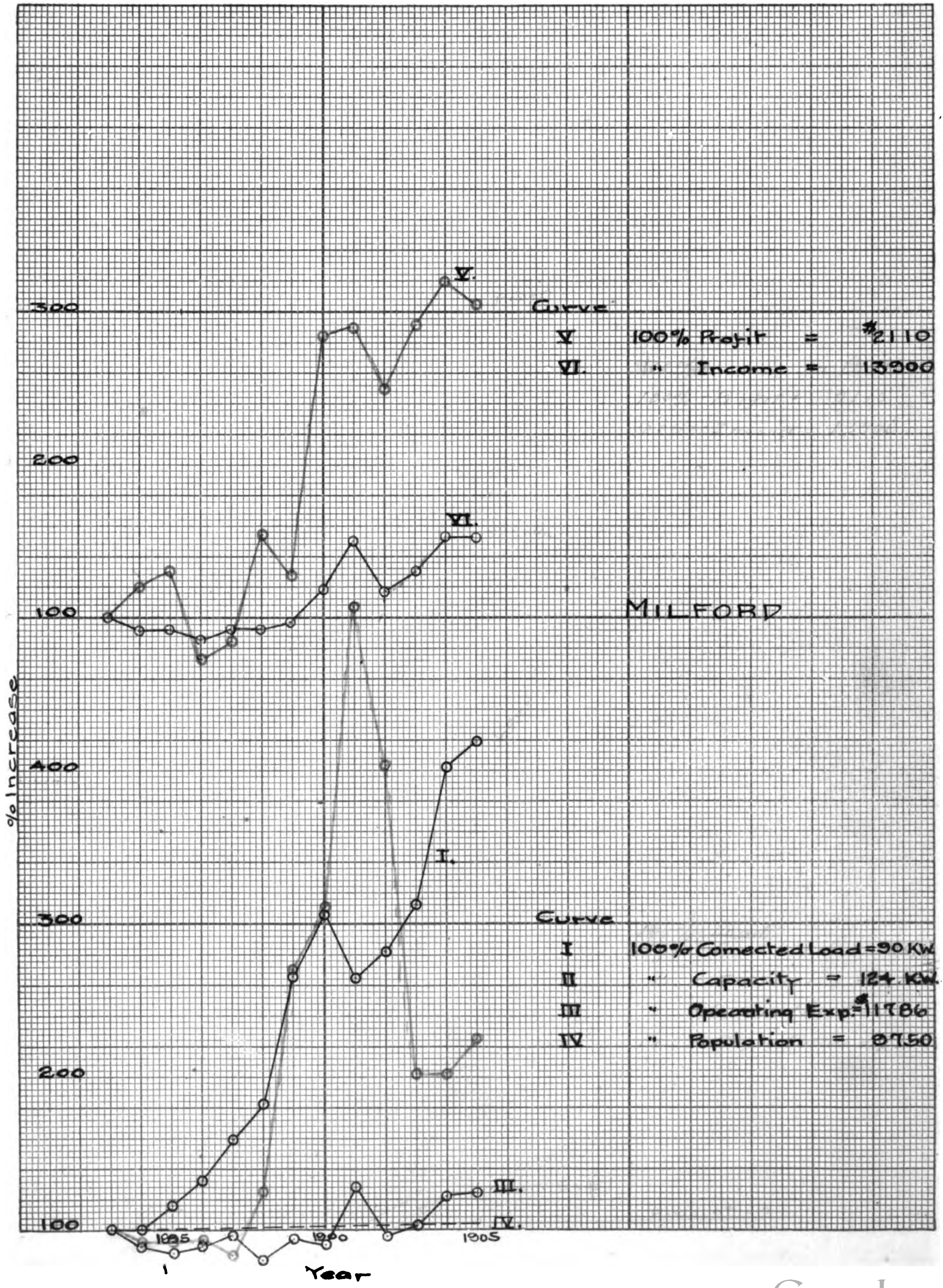
Table showing development and operating history of the United Electric Co.

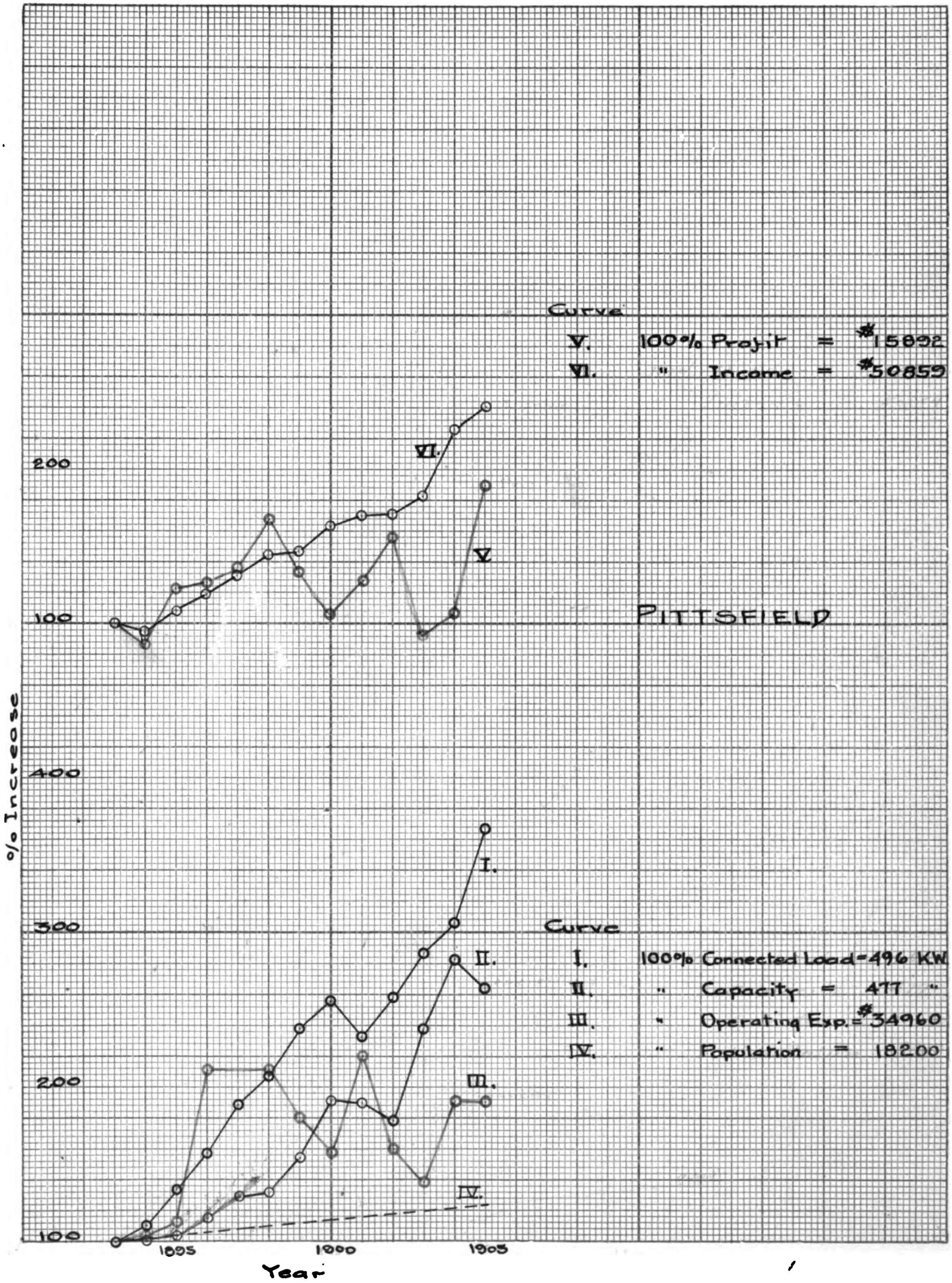
Year	1890	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04	'05
KW Capacity	1490	1544	1454	2040	3214	3421	2960	3145	3114	5090	5090	5480	8629
% of original capacity in '93	100	104	98	137	216	229	198	211	209	342	342	369	580
KW Connected load	847	1183	1487	1792	2149	2287	2657	2900	3597	3654	4681	5591	6688
% of original connected load	100	140	175	211	234	270	313	343	424	431	552	659	790
Total Income	$162.587	171350	161600	174080	177840	195610	201770	219904	231980	250000	278680	304900	342060
% of original income in '93	100	105	99	109	110	143	136	113	130	118	158	184	165
Operating Exp.	$89118	95600	88430	95670	97050	90580	102980	136650	136500	163593	162530	169800	220080
% of original operating expense	100	107	99	107	109	102	115	153	153	182	181	191	247
Profit	$73470	75750	73180	78683	80800	105030	98790	83527	95480	86400	116150	135074	121980
% of original profit.	100	105	100	.07	109	120	124	135	142	153	171	187	210
Pub. Light income	$62000	40620	43620	46580	49580	54082	57210	61925	65255	68255	72592	80500	82400
% Public of total	38	24	28	27	28	28	28	28	27	27	26	26	24
Valuation	$569230	661170	628000	659740	793940	862830	665070	696550	770160	993700	1208550	1263800	1550400
% Profit of valuation	12.9	11.5	11.7	11.9	10.2	12.2	14.8	11.9	12.4	8.7	9.6	10.7	7.8
Cost of operation per KW load	$ 60.00	62.00	60.70	46.80	30.20	26.40	.3480	43.50	43.80	32.20	32.00	31.00	25.50

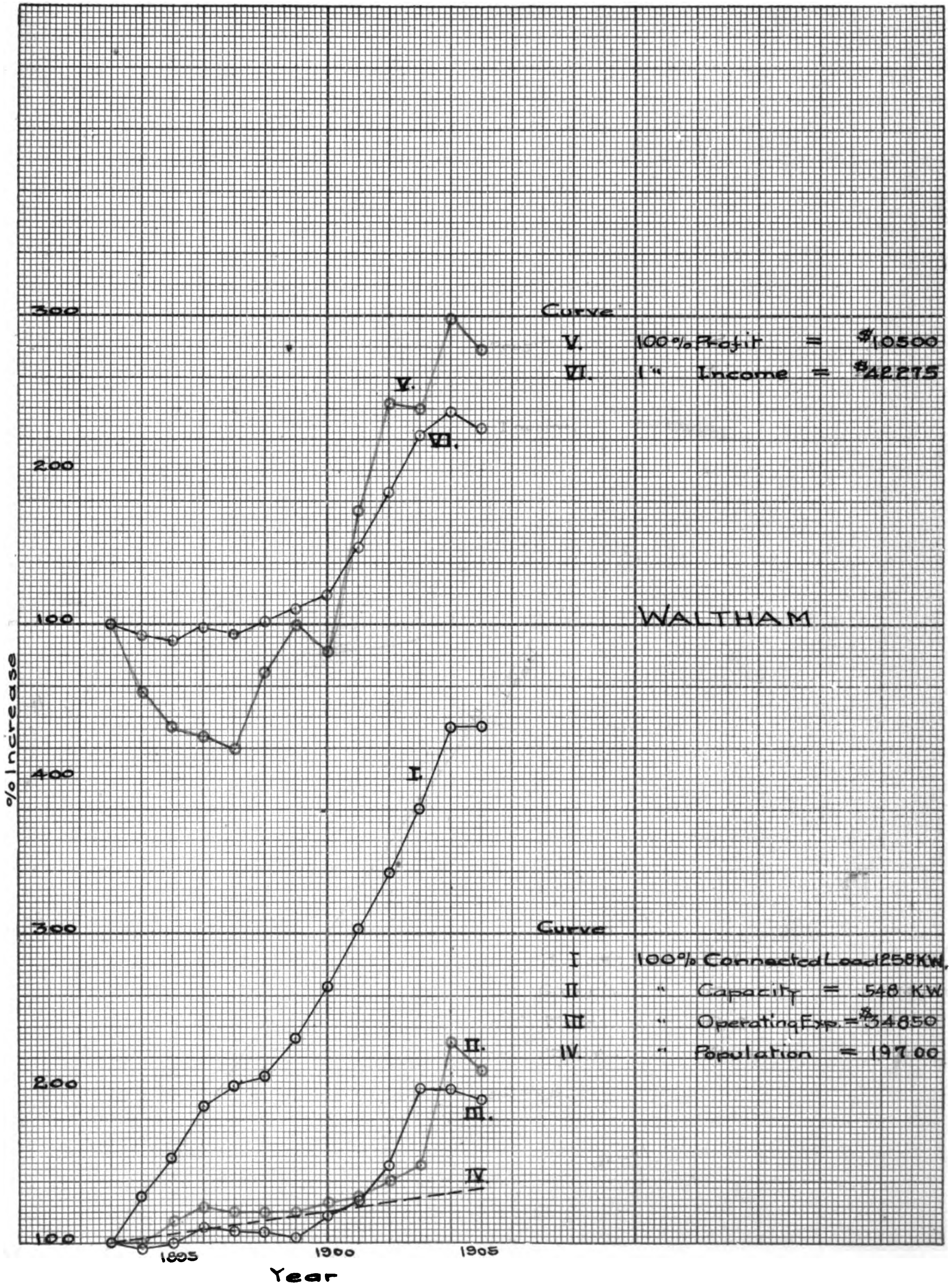
Table showing development and operating history of the Cambridge Electric Co.

Year	1893	94	95	96	97	98	99	1900	01	02	03	04	05
KW Capacity	637	700	795	910	979	1147	1430	1430	1760	3680	3130	2670	2300
% of original capacity in 93	100	110	125	143	171	180	225	225	277	579	419	419	362
KW Connected load	638	723	883	1174	1655	1885	2198	2743		2943	3196	3563	3913
% of original connected load	100	113	137	184	259	295	344	415		462	500	558	614
Total Income	$ 92073	103410	109640	111900	122230	130850	140990	158250	174120	178072	198062	225500	233100
% of original income in '93	100	113	121	123	133	144	154	175	182	196	217	245	256
Operating Exp	$ 58336	64761	68500	82280	86790	86331	81340	94530	112533	120970	142880	128131	121050
% operating expenses in '93	100	111	118	141	149	148	140	162	193	208	246	221	208
Profits.	$ 33000	38710	41150	37600	35438	44521	59650	63721	61593	57097	55190	97380	112060
% of original profits in 93	100	117	124	111	107	135	180	193	186	173	167	295	335
Pub light income	$ 53800	56900	62800	54330	62410	64550	65800		67820	70470	68980	70360	73540
% public of total income	58	55	55	49	51	49	47		39	40	35	31	31
Valuation	$ 462200	470158	467550	466400	480460	481150	475690	461590	433430	673643	739100	695000	817590
% Profits of valuation	7.1	8.2	8.8	8.1	7.4	9.2	12.5	13.8	14.2	8.5	7.5	14.0	13.7
Cost of operation per KW load	$ 91.60	89.50	78.00	70.00	52.40	45.70	37.00		41.00	41.00	44.80	36.00	31.00

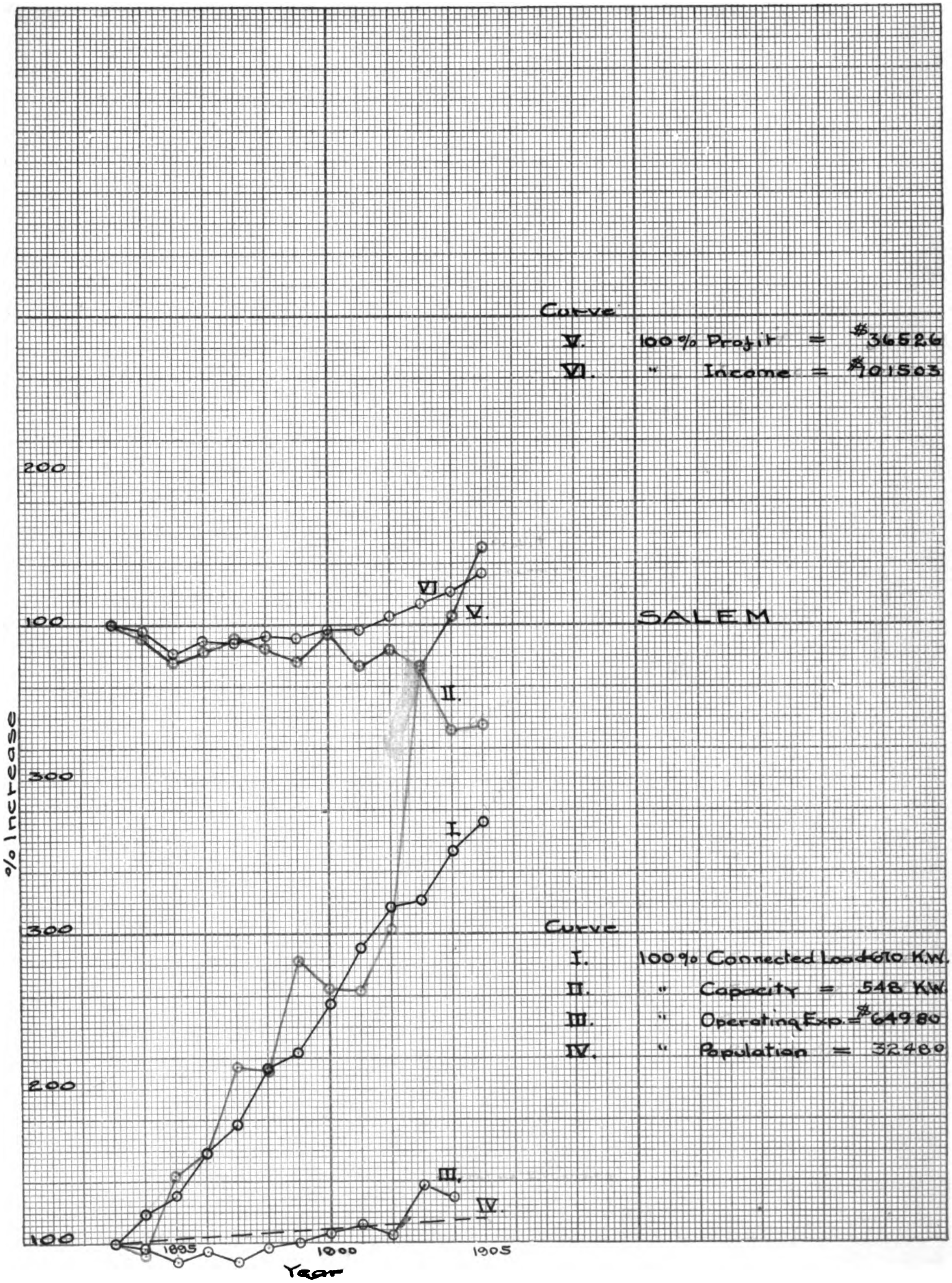

300
200
100
300
200
100
% Increase
1895
1900
1905
Year
V.
VI.
I.
III.
IV.
Curve
V. 100% Profit = $880
VI. " Income = $8782
UNION Franklin Norfolk
Curve
I. 100% Connected Load = 161 KW.
II. " Capacity = 42 KW.
III. " Operating Exp. = $7450
IV. " Population = 4900

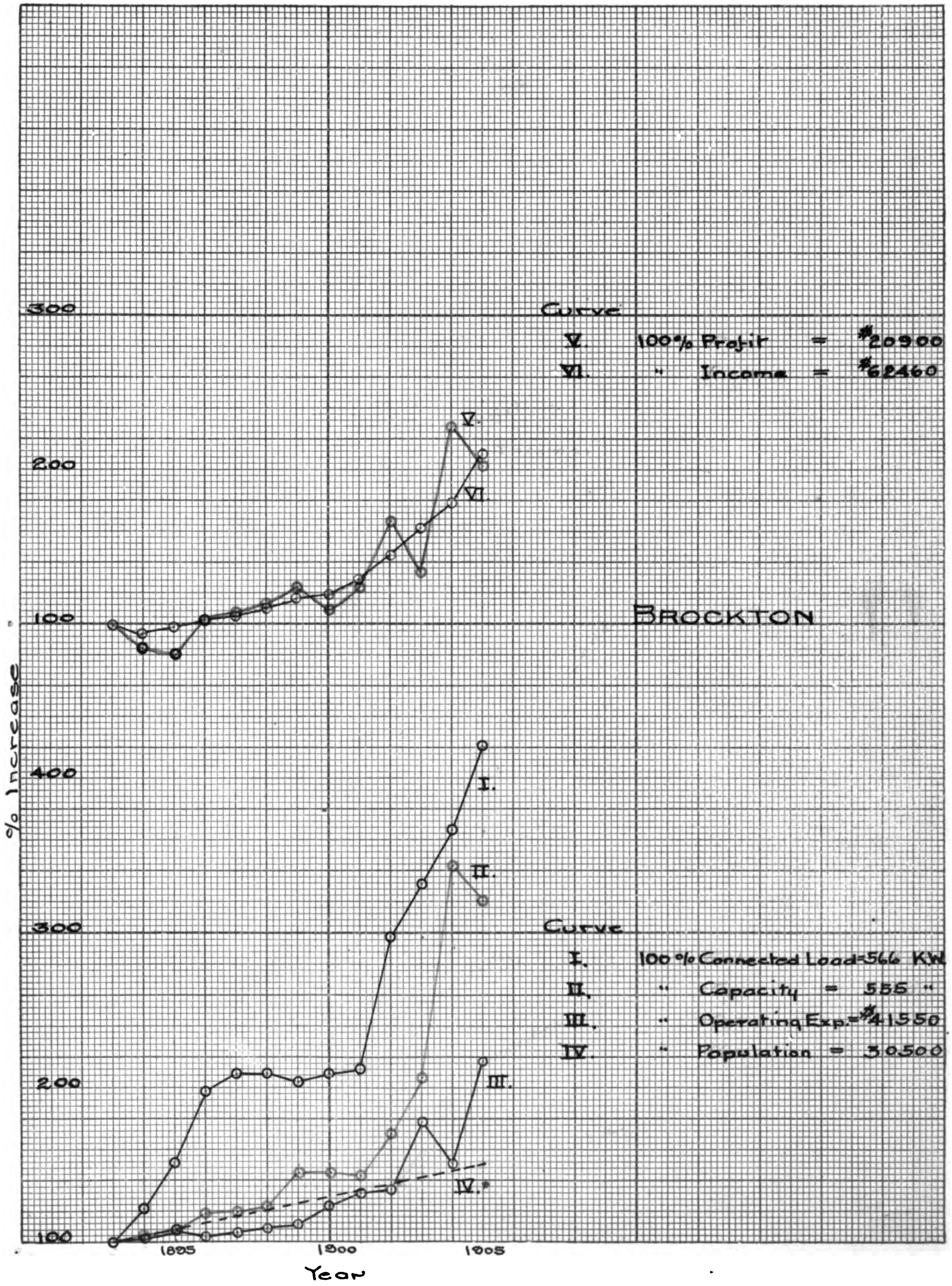

V.
300
Curve
V 100% Profit = $2110
VI. " Income = 13900
200
VI.
100
MILFORD
% Increase
400
I.
300
Curve
I 100% Comected Load = 90 KW.
II " Capacity = 124. KW.
III " Operating Exp. = $11786
IV " Population = 8750
200
III.
100
IV.
1895
1900
1905
Year

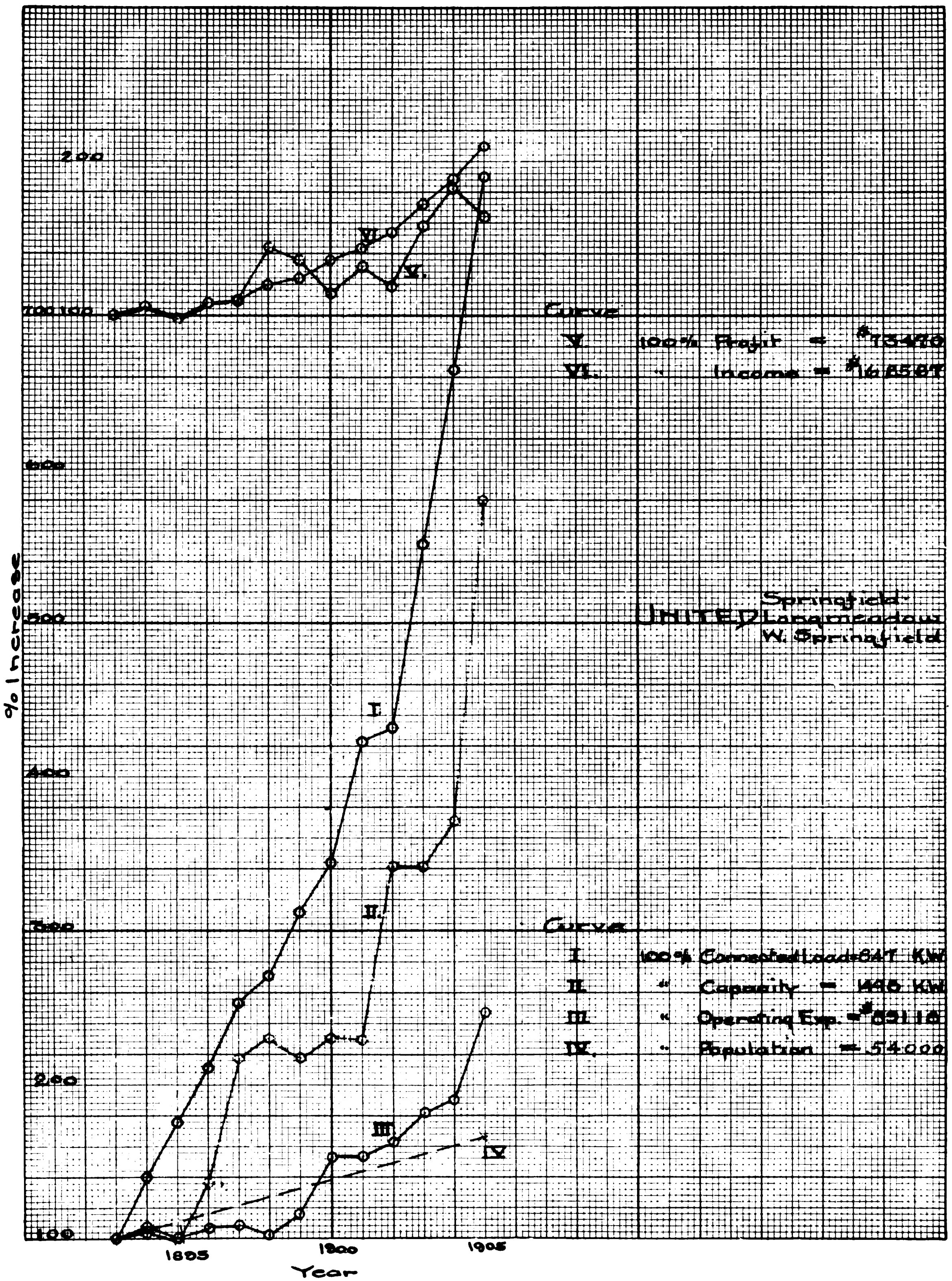

Curve
V. 100% Profit = $15892
VI. " Income = $50859
VI.
V.
200
100
PITTSFIELD
% Increase
400
300
200
100
I.
II.
III.
IV.
Curve
I. 100% Connected Load = 496 KW
II. " Capacity = 477 "
III. " Operating Exp. = $34960
IV. " Population = 18200
1895
1900
1905
Year

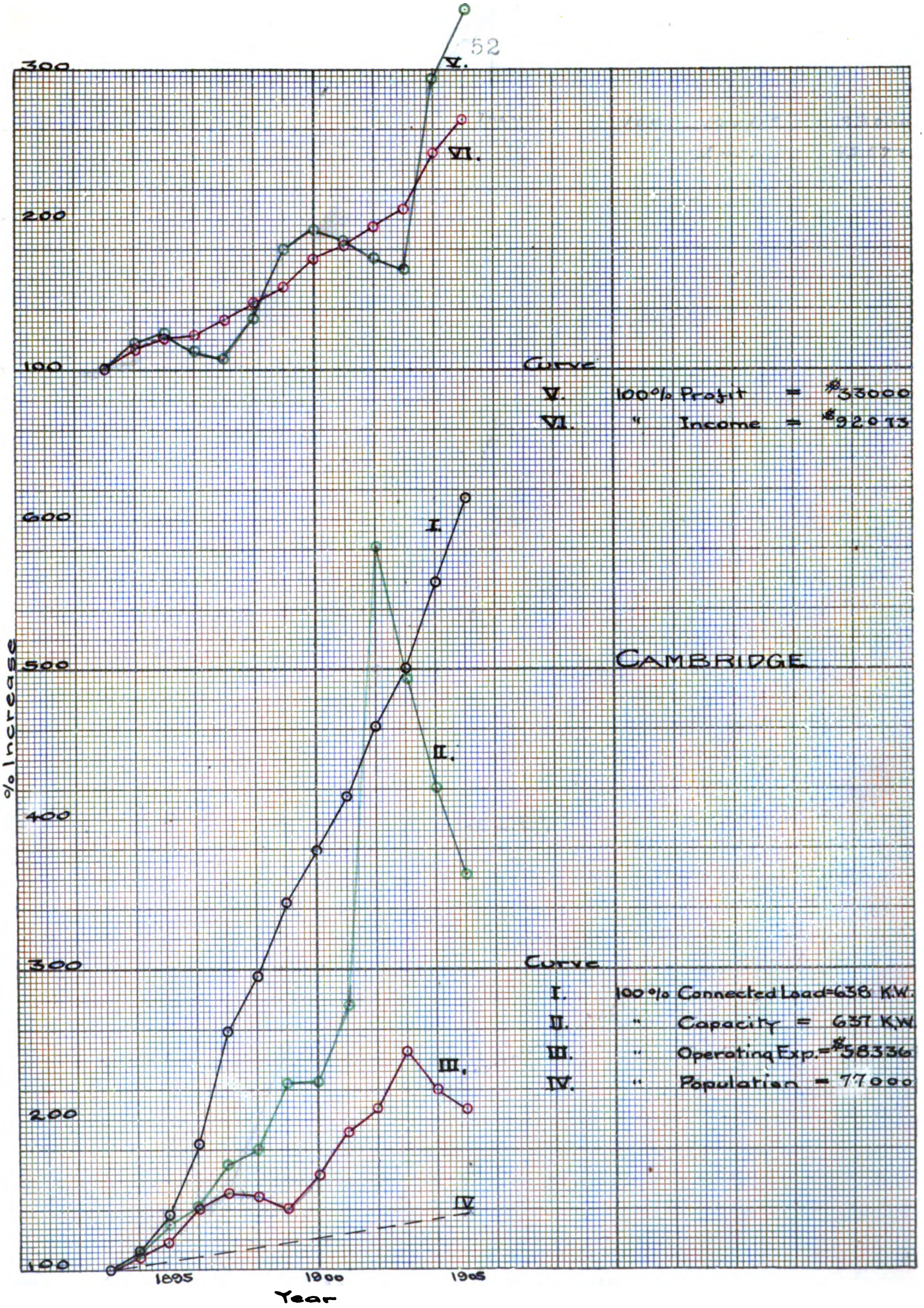


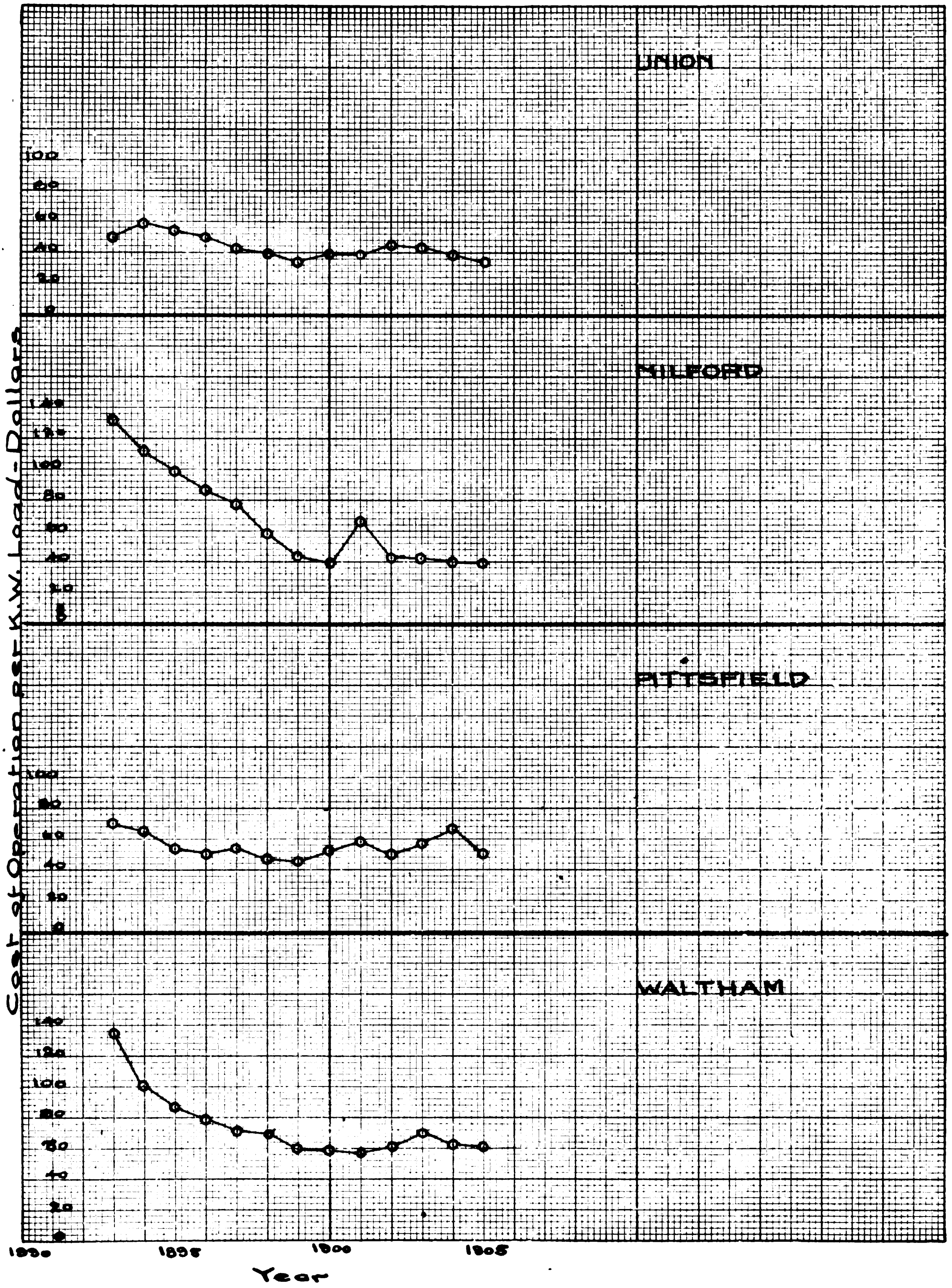
Curve
V. 100% Profit = $10500
VI. 1" Income = $42275
WALTHAM
Curve
I 100% Connected Load 258 KW.
II " Capacity = 548 KW
III " Operating Exp. = $34850
IV. " Population = 19700
V.
VI.
I.
II.
III.
IV.
300
200
100
400
300
200
100
% Increase
1895
1900
1905
Year

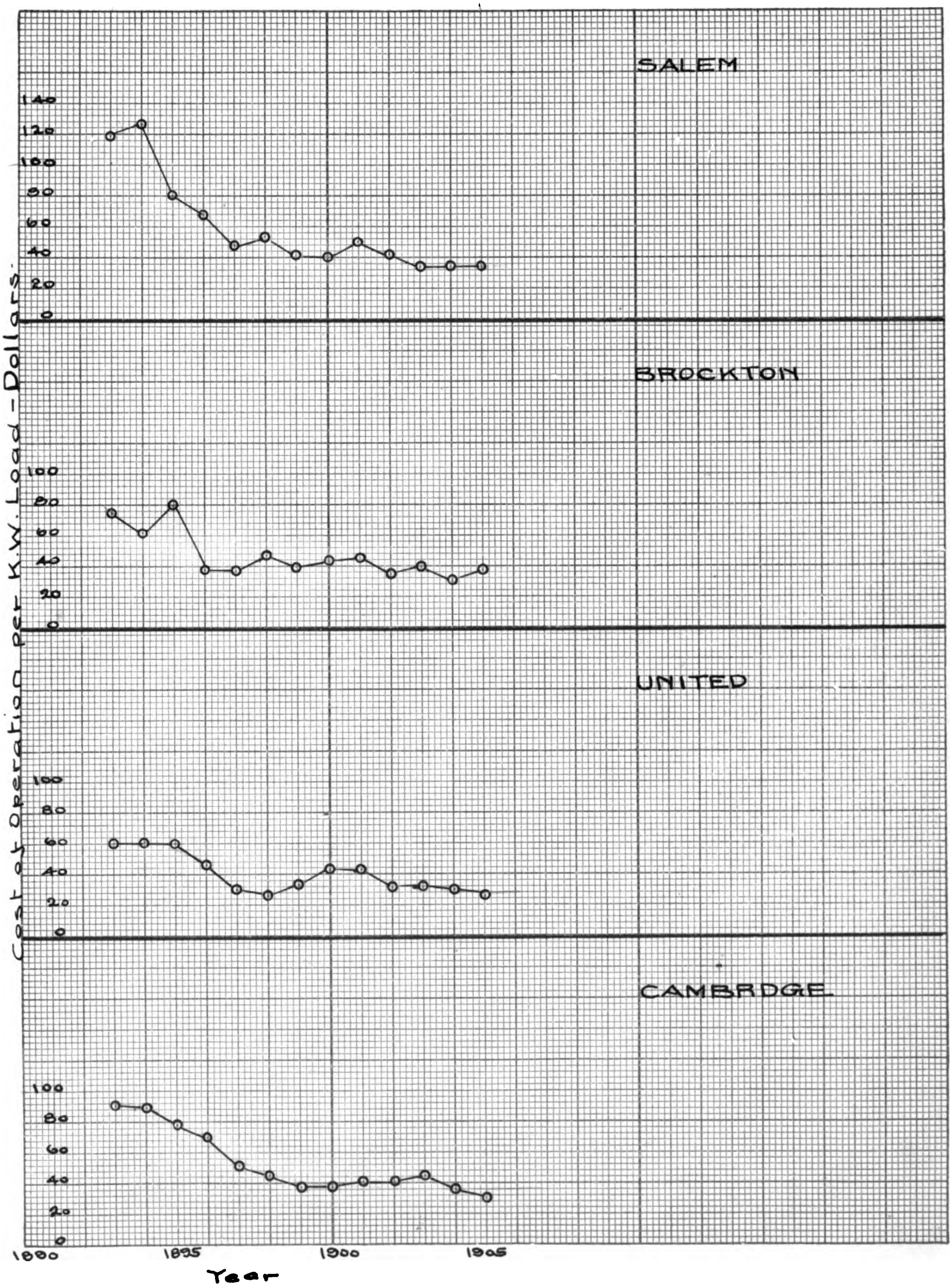

Curve
V. 100% Profit = $36526
VI. " Income = $101503
SALEM
VI
V.
II.
I.
Curve
I. 100% Connected Load 610 K.W.
II. " Capacity = 548 KW.
III. " Operating Exp. = $64980
IV. " Population = 32480
III.
IV.
% Increase
200
100
300
300
200
100
1895
1900
1905
Year

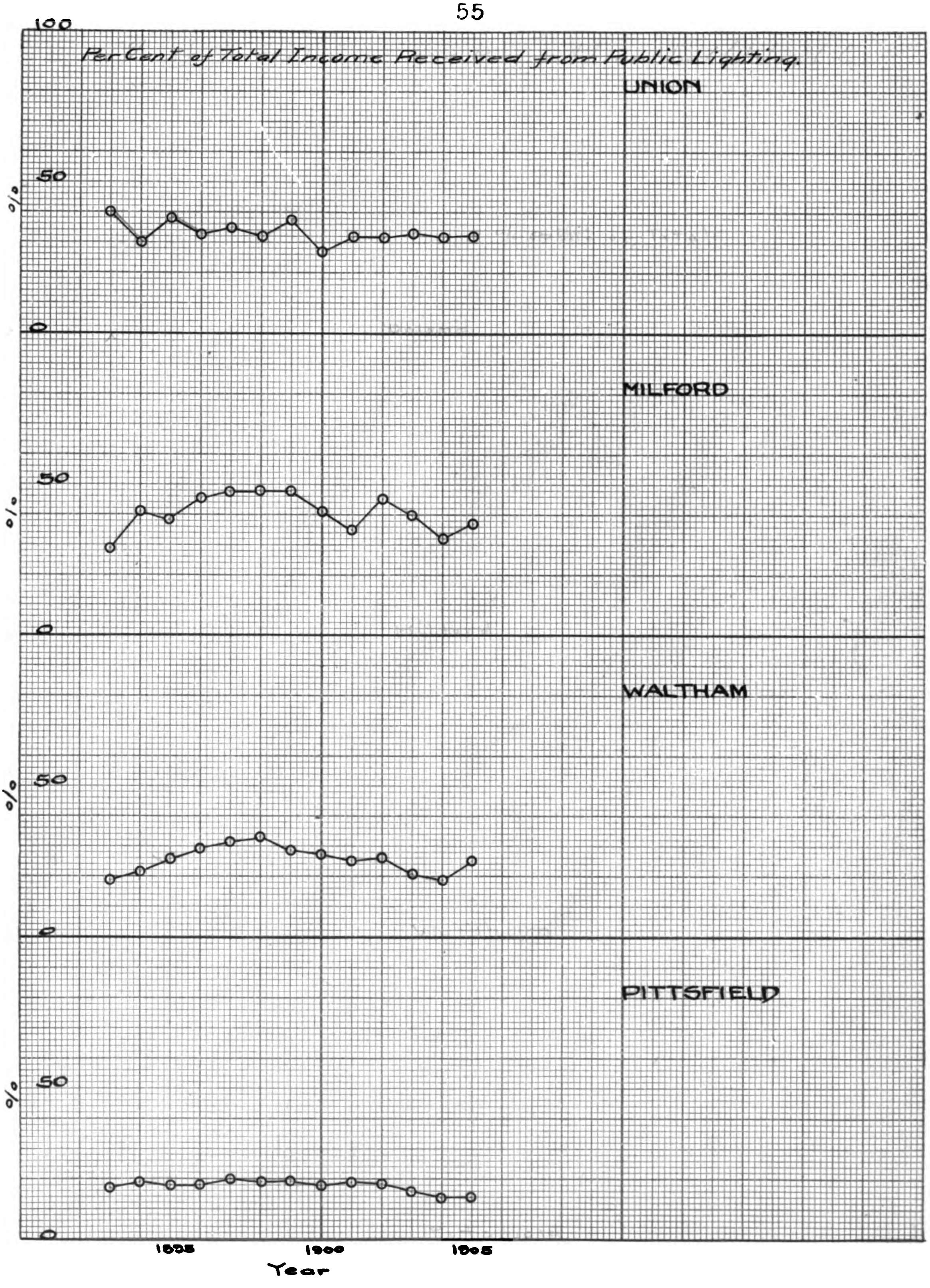

300
200
100
400
300
200
100
% Increase
1895
1900
1905
Year
V.
VI.
I.
II.
III.
IV.
Curve
V. 100% Profit = $20900
VI. " Income = $62460
BROCKTON
Curve
I. 100% Connected Load = 566 KW.
II. " Capacity = 555 "
III. " Operating Exp. = $41550
IV. " Population = 30500

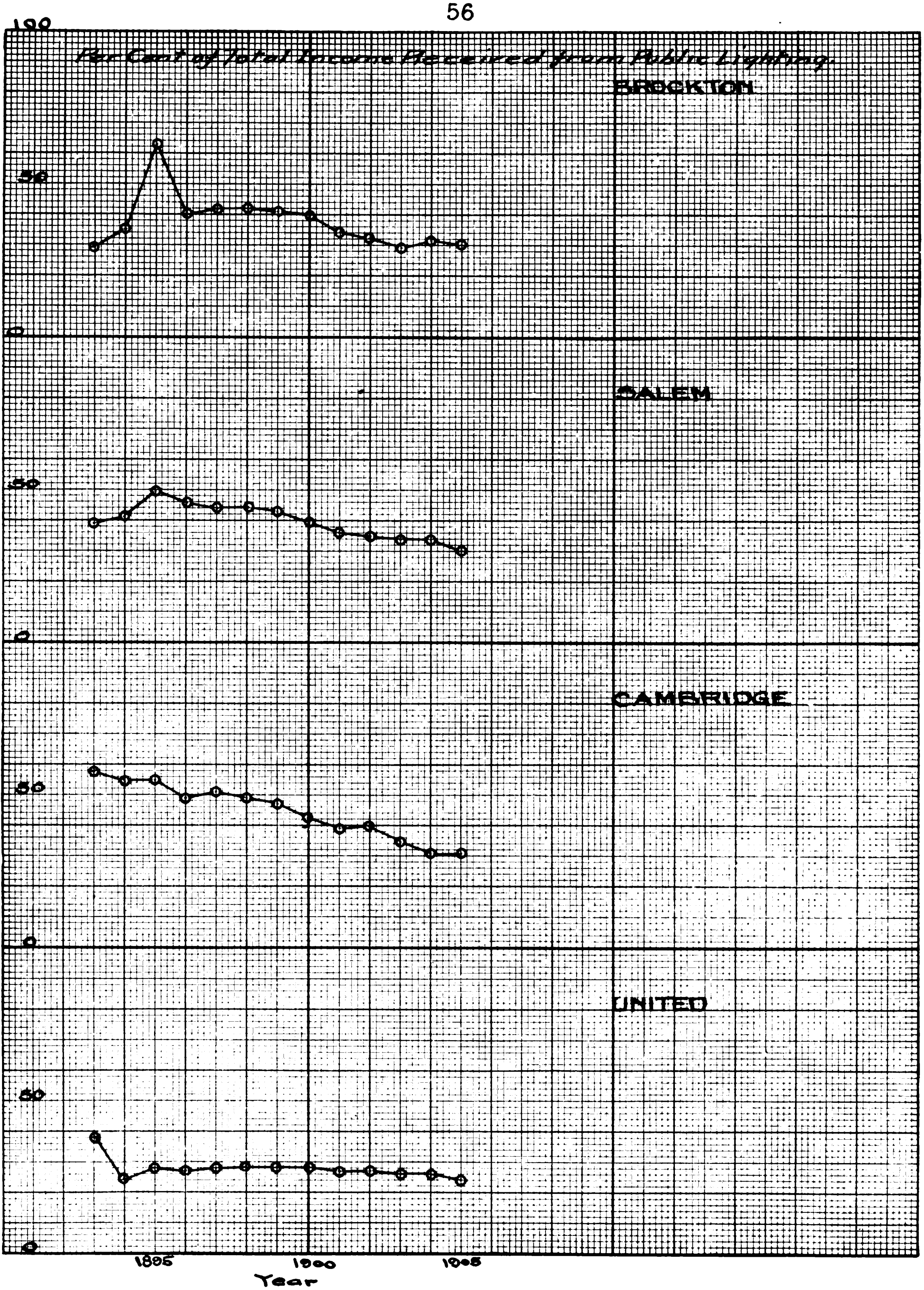

200
700 100
600
500
400
300
200
100
% Increase
1895
1900
1905
Year
VI.
V.
I.
II.
III
IV
Curve
V. 100% Profit = $13470
VI. " Income = $168587
UNITED Springfield Longmeadow W. Springfield
Curve
I 100% Connected Load=847 KW
II " Capacity = 1446 KW
III " Operating Exp. = $63118
IV. " Population = 54000


300
V.
VI.
200
100
Curve
V. 100% Profit = $33000
VI. " Income = $92073
600
I.
CAMBRIDGE
500
II.
400
300
Curve
I. 100% Connected Load = 638 K.W.
II. " Capacity = 637 K.W.
III. " Operating Exp. = $58336
IV. " Population = 77000
III.
200
IV
100
1895
1900
1905
Year
% Increase

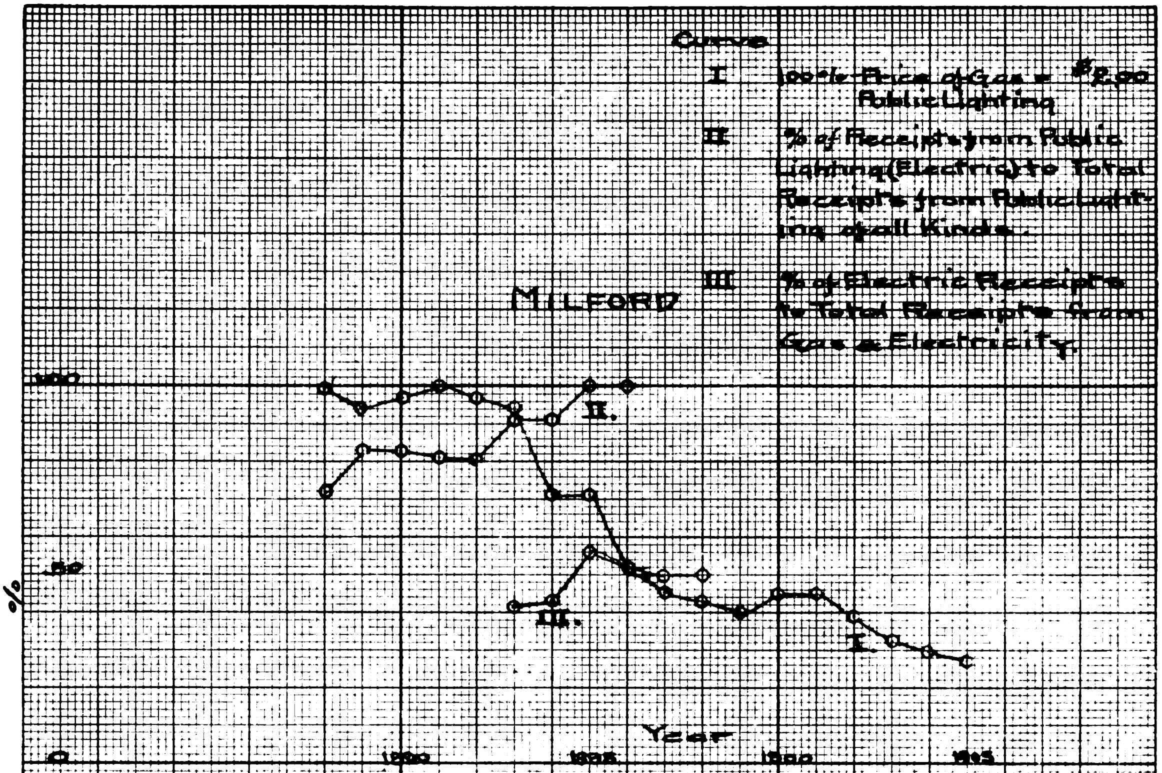

UNION
100
80
60
40
20
0
MILFORD
140
120
100
80
60
40
20
0
PITTSFIELD
100
80
60
40
20
0
WALTHAM
140
120
100
80
60
40
20
0
Cost of Operation per K.W. Load - Dollars
1890
1895
1900
1905
Year

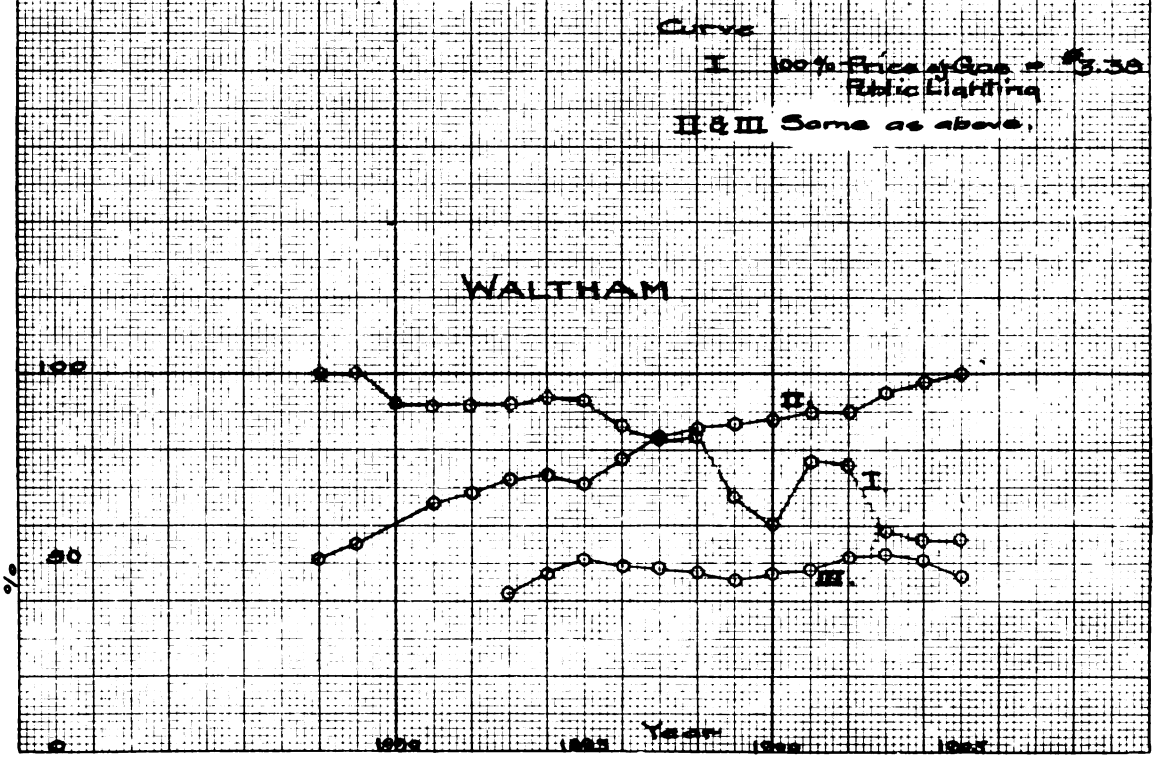

SALEM
BROCKTON
UNITED
CAMBRDGE
Cost of Operation per K.W. Load - Dollars
140
120
100
80
60
40
20
0
1890
1895
1900
1905
Year


Per Cent of Total Income Received from Public Lighting.
100
UNION
50
%
0
MILFORD
50
%
0
WALTHAM
50
%
0
PITTSFIELD
50
%
0
1895
1900
1905
Year



Per Cent of Total Income Received from Public Lighting.


Curve
I 100% Price of Gas = $2.00 / Public Lighting
II % of Receipts from Public Lighting (Electric) to Total Receipts from Public Lighting of all Kinds.
III % of Electric Receipts to Total Receipts from Gas & Electricity.
MILFORD
100
50
0
%
II.
III.
I.
Year
1890
1895
1900
1905


Curve
I 100% Price of Gas = $3.38 / Public Lighting
II & III Same as above.
WALTHAM
100
50
0
%
II.
I.
III.
Year
1890
1895
1900
1905

APPROVED: J. W. Shuster

asst. Prof of Elec. Eng.

89085090868

B89085090868A

89085090868

b89085090868a